The Journal of ELECTRICITY POWER and GAS

DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

VOL. XIII.—No. 7 SAN FRANCISCO, CAL., JULY, 1903. {YEARLY SUBSCRIPTION - $2.00 {SINGLE COPIES - 25 CENTS

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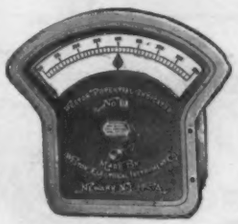

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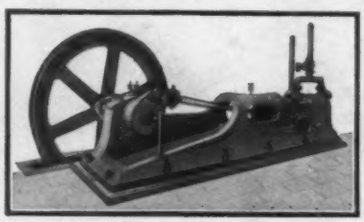

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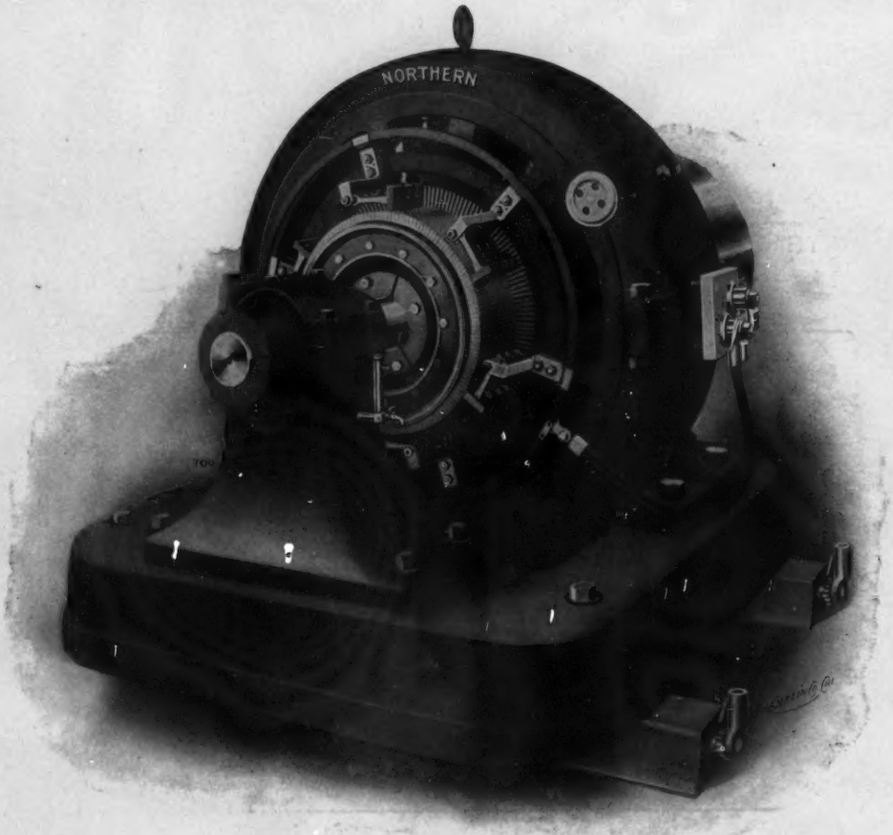

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Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XIII. SAN FRANCISCO, CAL., JULY, 1903. NUMBER 7

The Seventh Annual Convention of the Pacific Coast Electric Transmission Association.

Some of the Interesting Papers Contributed by Prominent Engineers and Read Before the Convention at San Rafael.

AFTER THE IONS—WHAT?*

BY ALEXANDER G. McADIE.

A MORE appropriate title for this paper would perhaps be "Preliminary Note on Experiments Relating to the Ionization of the Atmosphere." Plainly it is a proposed search in an unexplored region for infinitesimally small particles, using uncertain methods and apparatus that is very crude. Truly a venturesome quest. Something like the voyage of Magellan to unknown seas, with charts so crude that the navigator hardly needed to consult them in steering his course. But the journey must be undertaken, for daily it becomes more and more certain that man must leave the solid ground of things seen, heard and felt, and push out into that great sea where knowledge is not dependent on personal sensation. The radiant energy of the sun may well illustrate our ignorance. We measure possibly one one-thousandth of the ether waves. We can see light and feel heat—*i. e*, we have a nerve terminal sensitive to wave lengths from 700 micromils to 500 micromils: red to violet. With an artificial nerve terminal, or auxiliary eye—the photographic plate—we can feel ultra violet waves to 300 micromils; and with an artificial touch, or auxiliary finger—like Langley's bolometer—we can tell how hot or how cold it is in the infra red part of the spectrum. In all, the wave lengths run from Rubens and Nichol's longest waves, 240 $\mu\mu$ (944 millionths of an inch) frequency 12.5 billions (10^{12}) per second, to 1 μ (four millionths of an inch) frequency 3000 billions. As Professor S. P. Thompson states ("Light Visible and Invisible," page 197), "the infra red spectrum is about fifty times as large as the visible spectrum and the ultra violet region twenty times." And we are now getting ready to add to our make-up another auxiliary sense, through the radio-activity of certain substances. This last process will be of especial interest to us, as we are to deal largely with the electrons, or carriers of electric charge. The present year brings us face to face with the problem of how radium acquires its energy. And in accounting for the charge we will gradually come to live on terms of familiarity with the ion—the wanderer. The chemical unit, the atom, was once the limit; but now the electrical unit displaces it. The electron would be the atom of electricity, and the ion a group of these atoms. And these are indeed small neighbors for us to keep track of. Some authorities tell us there are twenty million million million molecules of hydrogen in a cubic centimeter, and an ion would be a thousand times smaller. Lord Kelvin estimates the diameter of a molecule to be between .01 and 2 $\mu\mu$, and its weight one ten-billionth of a billionth of a grain.

Now it is not exactly with the ion that we are to begin. There is a small body—a drop of rain—the commonest and apparently one of the least important of objects, yet in reality one of the most wonderful and least comprehended. It is as many times larger than the ion as the world is larger than the mote in the sunbeam. Its mechanism is as wonderful as the mechanism of the universe. Before this convention last year it was stated that the physicist who shall give us the life history of a rain drop or a fog globule, telling us of the excursions of the ions, will open up for practical development the most wonderful field science has yet prospected in. Nearly all of the experimentation (and there has been not a little in the past five years) on the electrification of the atmosphere, the origin of atmospheric electricity, the causes of the sudden development of enormous potentials and the equally sudden dissipation of the same, has been along the lines of air ionization. Thus, Elster and Geitel, Rutherford, C. T. R. Wilson, Gockel are but a few names of many who are studying the radio-active properties of rain; detecting the radio-activity as a rule, by changes in the ionization of the air. Already we know that moisture seems to favor the absorption of negative ions; that negative ions are more effective nuclei of condensation than positive ions; that rain drops already formed carry negative electricity to the earth. Gockel has given us the results of work done by fog in influencing the mobility of ions. At Freiburg he found a quicker dissipation of positive electricity with a falling barometer. A surplus of positive ions was removed by fog. During snow storms there was a quicker dissipation of positive electricity, and therefore a prevalence of negative ions. Ebert finds by balloon voyages a strong surplus of positive ions in the layer of air just above the fog. And so it runs. Many are investigating, each contributing to carry the work a step further. We have good ground for believing that before long we shall understand something of the play of the ions in connection with the electricity of the air.

And if you ask me what the practical outcome of such work may be, I answer: First, knowledge of atmospheric

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

conditions will enable us to master problems relating to static charges. Again, the whole question of insulation, wherever glass, porcelain or any hygroscopic surface is exposed to air, hangs upon ionization; that is, the condensation of water vapor depends probably upon the work of the ions.

Who shall say that it may not be possible to do away with much of the intermediate apparatus now required in furnishing light. At present we are like the singer who runs the scale every time a certain note is desired. There must be some way of utilizing more directly radiant energy than by damming water to furnish power to run dynamos to furnish current to be distributed via mains and insulators to render incandescent a filament of carbon.

SINGLE-PHASE MOTORS ON MULTI-PHASE PLANTS.*

BY H. A. BULLARD.

IN the minds of a great many people an idea exists that the only reason for the manufacture of a single-phase motor is that the patent situation in connection with polyphase motors is such that the single-phase motor is the only type left for those outside of the combination to handle. The multi-phase motor has a field of importance which is certainly very broad, but it is no less true that the single-phase motor has a field of its own, and a broad one, too.

It is not alone a valuable adjunct for single-phase stations, but an exceedingly valuable adjunct for all polyphase plants, and a permanent demand for single-phase motors is growing to such an extent that they will eventually be required by polyphase stations for motors up to certain sizes on account of the lower first cost of line construction, transformers, etc.

Several attempts have been made at various times to develop a suitable single-phase motor, and the disaster which has attended the majority of these efforts has been the means of creating a prejudice which it has taken long to overcome. It should be matter of congratulation to all concerned in the sale of electrical power that a successful motor of this character is now on the market. You, of course, appreciate at once that this refers to the single-phase motor made by the Wagner Electric Manufacturing Company, at St. Louis.

In mechanical construction this motor is in many respects similar to that of the multi-phase motor now upon the market. A field and armature core are built up of iron plates or laminations very much like those used in the multi-phase motor. The field is wound of so-called pancake coils, threading through the slots of the punchings, thus producing a magnetic pole of intensity varying from a maximum, at the center, to zero, at the edges. The armature core is wound with an ordinary direct-current progressive winding, connected up to a commutator in exactly the same fashion as is the direct-current motor armature winding, but the commutator for this armature is designed so that it may be completely short circuited by introducing into contact with it a short circuiting circle of copper segments. When short circuited the windings afford a substitute for the so-called squirrel cage form of winding, or its equivalent, used in the multi-phase motor. It only differs from this squirrel cage winding in that instead of currents being able to select paths for themselves, they are restricted to flowing in paths afforded by the individual coils.

The operation of this motor is based wholly upon the principle that an induction motor with a completely short circuited armature will, when up to the running speed, operate on single-phase current supply in exactly the same manner as does a multi-phase motor with two or three-phase current supply. The feature, however, which distinguishes this particular motor from any other single-phase motor, or, in fact, from the multi-phase motor, is the starting device, and without entering into its full description, suffice it to say that it consists of a special commutator with surface at right angles, instead of parallel, to the shaft, and carbon brushes controlled by an automatic device which breaks them away from contact with the commutator as the motor approaches full speed, and further allows the brushes to return to contact with the commutator as the motor slows down for any reason. This device also automatically short circuits the commutator, or vice versa. It is entirely automatic in its operation, and whereas objection is raised to the matter of commutator and brushes, this objection immediately assumes insignificance when one considers that the brushes are on the commutator only for a very few moments at the time of starting, hence there is practically no wear and tear on the commutator, nor, in fact, on the brushes. Many motors of this type installed three years ago have never yet had their brushes replaced, nor the commutator turned off at all, and the fact that this device is capable of adjustment means that the motor can be arranged for starting almost any degree of overload.

As to the starting characteristics of torque and current, this motor corresponds closely with a series direct-current motor. It is so designed as to carry a large percentage of overload without any serious consequence, and if this capacity for overload is exceeded the motor will slow down until the brushes return to contact with the commutator, when it will speed up somewhat and carry the load (if not extremely heavy) until the overload disappears. However, the motor should not be allowed to operate under these conditions except for a very short period of time. Extremely excessive overload will of course cause the motor to come to rest. If the overload is temporary, the motor will, without attention, run back up to speed, since if slowed down the brushes are automatically thrown back on the surface of the commutator and the motor is again placed in a starting condition. The motor can be arranged for a large starting torque, and in extreme cases, even up to 100 per cent. overload, may be brought up to running speed. It can be connected upon the same circuit with incandescent lamps, and operated thereon without any disadvantageous effects.

The following will be of interest and answers what will doubtless be the first question arising under the present circumstances, namely, "Why should multi-phase stations

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

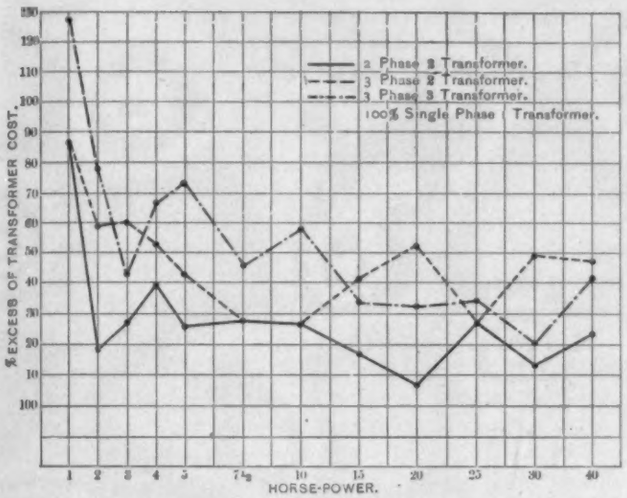


FIGURE 1. CURVES SHOWING EXCESS OF FIRST COST OF TRANSFORMERS FOR MULTI-PHASE MOTORS AS COMPARED WITH SINGLE-PHASE.
(These curves are based on price list of one of the large companies.)

install single-phase motors?" Two or three-phase motors require either two or three transformers, three or four primary wires, three or four secondary wires from the transformer to the motor, extra cross-arms on poles, extra insulators and other matters of like character involving a considerable excess of cost. As indicating this excess cost of transformers alone, refer to Figure 1, which speaks strongly. Observe that the excess cost of transformers alone varies from an average of about 25 per cent. for two-phase motors to an average of about 50 per cent. for three-phase motors, operating on two transformers. A large excess of transformer losses with either two-phase or three-phase motors is apparent when compared with single-phase motors of the same size. Figure 2, showing such losses plotted from the published losses of transformers of one of the large manufacturing concerns is convincing in character.

Another strong point in favor of the use of these motors on multi-phase plants is the greater ease of controlling the starting current by means of a non-inductive starting box. The Wagner company's single-phase motor can be started under full load, the current not exceeding the full load current by 25 per cent., and with a power factor not falling below 80 per cent. With the polyphase motor, owing to the necessity for controlling the current in two or three circuits instead of one, all starting devices so far supplied are necessarily of a complicated character, if in the form of resistance, and when not in the form of resist-

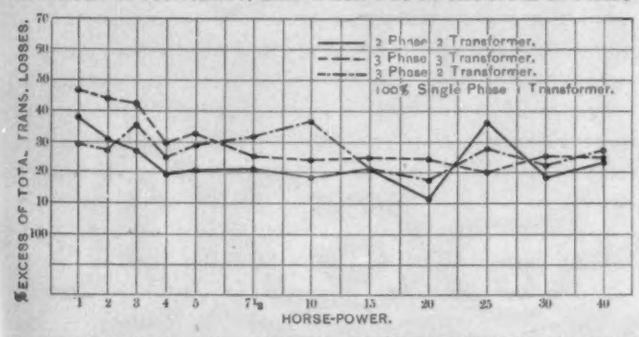


FIGURE 2. CURVES SHOWING EXCESS OF TRANSFORMER LOSSES FOR MULTI-PHASE MOTORS AS COMPARED WITH SINGLE-PHASE.

ance are ineffective. In Figure 3 appears the results of a test made by the Brooklyn Edison Company to determine the effectiveness of non-inductive starters, and in this note that the full load was brought up to full speed without exceeding full load current, which is a somewhat better result than would be shown in the average motor, the standard being that full load can be brought up to full speed and the starting current not exceed 25 per cent. above the full load current. This test, as illustrated in Figure 3, is also interesting on account of the "hump" in the torque curve of the diagram for starting condition without non-inductive starter. This illustrates that which the motor is capable of doing in the way of bringing up exceedingly heavy loads. Elevator work usually requires a torque curve of this character.

Many engineers have doubtless experienced the troubles due to current leaving the long distance high potential transmission line when short circuits or other troubles have occurred, and the various motors have been shut down; and when all connections have been re-established and current has again been put on the line, junction and

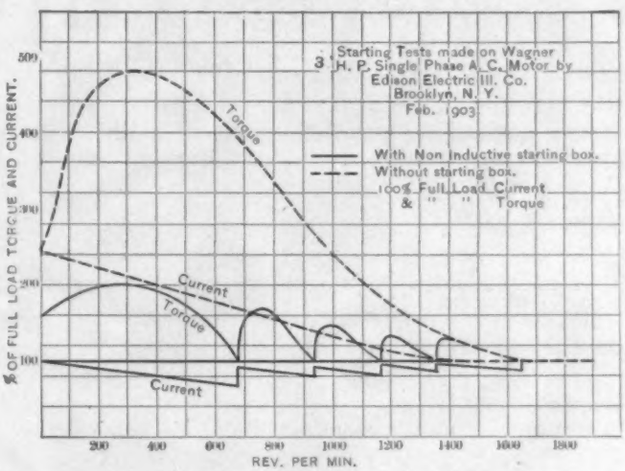

3 Starting Tests made on Wagner H. P. Single Phase A. C. Motor by Edison Electric Ill. Co. Brooklyn, N. Y. Feb. 1903
Torque
With Non Inductive starting box.
Without starting box.
100% Full Load Current
& " " Torque
Current
Torque
Current
% OF FULL LOAD TORQUE AND CURRENT.
REV. PER MIN.

FIGURE 3. STARTING TESTS MADE BY BROOKLYN EDISON COMPANY ON THREE-HORSEPOWER WAGNER SINGLE-PHASE MOTOR.

motor fuses galore would blow, all due to the fact that many motors were not properly handled when the current left the line. This, of course, is very annoying, not only to the power company, but also to the customer. On some of these polyphase transmission lines Wagner single-phase motors are being used almost exclusively for driving small pumping plants, for the reason that their starting current under these conditions will not blow the fuses. In one case, all small polyphase pumping plants, where no attendants could be provided, were withdrawn, as the power company refused to furnish current for the same excepting where they were replaced with Wagner single-phase motors.

The argument most often used against single-phase motors is that they constitute an unbalanced condition on the line, and hence a disturbance of a character which may become objectionable. This trouble, where it has been experienced, has been largely due to the inherent regulation, primarily of the generators and secondarily of the lighting and power system as a whole, and with the

better regulation and better conditions obtained with standard apparatus of today this trouble is not experienced. Moreover, with the extremely large generating plants now in general use this disturbing factor becomes practically nil, since the larger the generator capacity as compared to the motor capacity, the less will be the disturbing effect. As showing how little this effect really is note the following table, showing sizes of generators and of the Wagner single-phase motors which they are operating:

MUNICIPAL ELECTRIC LIGHT PLANT, HENDERSON, KY.

Generators:
- One 75-kilowatt, 60-cycle.
- One 150-kilowatt, 60-cycle.

Wagner Motors:
- One 10-horsepower operating buggy factory.
- One 7.5-horsepower operating passenger elevator.
- Two 4-horsepower operating meat grinders.
- One 4-horsepower operating printing office.
- Two 3-horsepower operating printing office.
- One 2-horsepower operating bottling works.
- One 1-horsepower operating job printing office.
- One ½-horsepower operating six ceiling fans.
- Total horsepower in Wagner motors, 36½-horsepower.

WHITEHALL ELECTRIC COMPANY, WHITEHALL, ILL.

Generators:
- One 75-kilowatt, 60-cycle.

Wagner Motors:
- One 25-horsepower operating city pumping plant.
- One 25-horsepower operating clay crusher in jug factory.
- One 10-horsepower operating pottery factory.
- Ten motors, miscellaneous sizes, operating printing offices, elevators, pumping water for stock farm, grinding feed, etc.
- Total horsepower capacity in Wagner motors, 100 horsepower.

LAUREL IMPROVEMENT COMPANY, LAUREL, MISS.

Generators:
- Two 90-kilowatt, 60-cycle.

Wagner Motors:
- One 30-horsepower operating wagon factory.
- One 30-horsepower operating railway machine shop.
- One 30-horsepower operating cross-arm factory.
- One 15-horsepower operating knitting mill.
- One 10-horsepower, two 4-horsepower, one 3-horsepower, two 2-horsepower, operating miscellaneous plants.
- Total horsepower capacity in Wagner motors, 140 horsepower.

CRESCO LIGHT, HEAT AND POWER COMPANY, CRESCO, IOWA.

Generators:
- One 75-kilowatt, 60-cycle.

Wagner Motors:
- One 15-horsepower operating woodworking shop.
- One 10-horsepower operating grain elevator.
- One 10-horsepower installed on farm, operating feed cutters, deep well pump, cream separators, etc.
- One 7.5-horsepower operating machine shop.
- Three 1-horsepower operating printing presses and ice cream freezer.
- Total horsepower capacity in Wagner motors, 45 horsepower.

The larger the number of single-phase motors installed on a multi-phase system the more easy it becomes to balance the load when the regulation of the system is so poor as to require close balancing.

Some of the strongest advocates of single-phase motors are plants having multi-phase generators only, and among the best engineers in this country are several who concede the great advantage of installing single-phase motors, the only difference of opinion between them being the limit of size they will permit to be installed on their multi-phase circuits. Here on the Pacific Coast Wagner single-phase motors are operating up to and including twenty horsepower, and many of the power transmission companies have indicated their willingness to furnish current to any size of these motors up to and including forty horsepower. The following list of Eastern stations and their policies are suggestive:

Name of Company	System of Distribution	Size of Single-phase Motors Installed.
Chicago Edison Co., Chicago, Ill.	Three-phase, four wires	Single-phase exclusively up to and including five horsepower.
Columbus Edison Co., Columbus, Ohio.	Two-phase	All sizes. Larger sizes with non-inductive starter.
United Electric Co., of New Jersey	Two-phase	All sizes. Larger sizes with non-inductive starter.
Cleveland Electric Illuminating Co.	Three-phase.	Three horsepower or less.
Brooklyn Edison Co., Brooklyn, N. Y.	Two-phase	Five horsepower or smaller. Larger sizes depend on location.
Missouri-Edison Electric Co., St. Louis.	Monocyclic and two-phase generators, single-phase distribution	Single-phase motors only.
Washtenaw Electric Light & Power Co., Ann Arbor, Mich.	Three-phase generators, all sizes, single-phase distribution	All sizes.

Practically every large central station, two-phase or three-phase, now uses these single-phase motors, and the list above is simply cited as giving typical examples. The General Electric Company states as follows in one of its regular published bulletins:

For lighting with incidental power, in small motors, single-phase alternating current motors afford a great advantage by their simplicity, so that even when a polyphase system is used, for small owners it is generally more convenient to use single-phase motors.

A very important consideration in securing satisfactory services for any kind of alternating current motor, single-phase or polyphase, is the maintenance of the proper pressure. The load capacity of an alternating current motor drops off very rapidly as the pressure falls below the normal, while for pressure above the normal the motor capacity increases very rapidly. It is therefore not objectionable to run the motors on pressures varying from 10 per cent. to 15 per cent. above the normal, though it is very serious to run on pressures below the normal. This fact makes transformer regulation a very important consideration to good alternating current motor service, and it has been the experience of a great many central station men that some of the makes of core type transformers now on the market give exceedingly poor regulation on motor loads, and that even the best types of core transformers are inferior to the shell type in this respect. The proper kind of transformer need not be wound with a special ratio for motor work.

A COMING PROBLEM FOR THE PACIFIC COAST ENGINEER.*

BY W. F. LAMME.

A PIPE line has been constructed to conduct oil from Bakersfield to Point Richmond, on San Francisco Bay. This pipe line is now being filled with oil, and oil cannot be delivered at Point Richmond until the filling of the pipe line is complete.

A long distance transmission line has a characteristic analogous to this pipe line—it must be filled before delivery begins. This filling quantity is the charging current.

With alternating current the line is filling and emptying, alternately; therefore, the amount of charging current is proportional to the number of times per minute that the filling and emptying takes place.

Like matter, current has another characteristic—it has inertia. It resists being established, and when once established it resists being disestablished — it resists change.

Alternating current is undergoing change continuously; therefore, with alternating current, this resistance to change is always in evidence.

This resistance is what we call self-induction, and the electromotive force resulting from it is the electromotive force of self-induction. Self-induction is proportional to the number of times per minute that the current changes.

Combinations of the two above are liable, under certain circumstances, to set up dangerous line oscillations.

Electric energy can be produced in one place and delivered to another place many miles away, the usual source of power for producing electricity to be transmitted being water.

In competition with the above, electricity is produced at the place of consumption, usually through the employment of fuel. Electricity from water and a long distance line is in direct competition with that produced usually by steam. It is not our intention to discuss the water power, but the line feature of long distance transmission.

On the Pacific Coast today, most of the transmitting is done at 7200 and 6000 alternations per minute. Is this the cheapest and most satisfactory form?

Let us compare. Take a single three-wire, three-phase line, 200 miles long, 50,000 volts delivered,

With 7200 alternations 6,000 horsepower are delivered.
With 3000 alternations 15,000 horsepower are delivered.
With 2000 alternations 22,500 horsepower are delivered.

That is, to deliver 40,000 horsepower would require:

With 7200 alternations..... 7 pole lines.
With 3000 alternations..... 3 pole lines.
With 2000 alternations..... 2 pole lines.

The chief argument advanced for the employment of 7200 alternations, instead of lower, is that arc lighting can be done directly off the circuits. If arc lights were produced by other means, then the alternations per minute could be reduced to a number where incandescent lamps could still be used without disturbance to consumer—that is, about 3000.

The use of 3000 alternations, instead of 7200, has many advantages:

1. Much more energy can be transmitted over a single pole line.
2. Operation of rotaries for railway and other purposes is comparatively easy, even with wide fluctuations of voltage.
3. Operation of variable speed, alternating current motors, such as required for mine hoists and elevators, is not difficult.
4. Line disturbances are much lessened, and therefore higher voltages on the main line can be employed with the same risk.

There is coming into use alternations still lower than 3000—that is, 2000. Two thousand alternations while having some disadvantages, still have other decided advantages over 3000 alternations:

1. The current can be applied directly to railway work.
2. Variable speed motors of all kinds, such as for hoists and elevators, can be employed most satisfactorily, efficiently and economically.
3. More energy can be transmitted over a single pole line.

However, for all kinds of lighting, the current must be transformed from 2000 alternations to higher, or to direct current. This can be done through phase changers or rotaries or motor generators.

From the above it is evident that when energy in large quantities is transmitted from the foothills of the Sierras to the coast cities, the present systems will be found wanting.

How can the present number of alternations be changed from high to low? This is the problem I present to you. A solution must be found.

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

SOME NOTES ON ALTERNATING AND DIRECT CURRENT ARCS.*

BY P. C. BUTTE.

THE subject of illumination is recognized by all modern lighting companies as one of vital importance. The proper selection of lamps, their location and installation, should conform with the fundamental laws of illumination; and good lighting can be obtained only by a careful consideration of these laws.

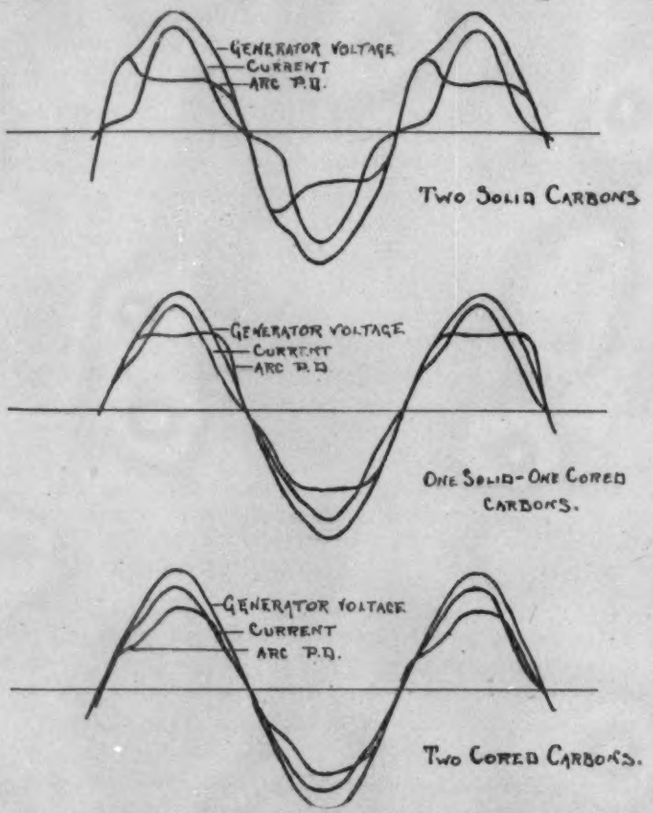
Heretofore, brilliancy was usually considered the only essential qualification of a good light, but this fallacy was soon corrected by comparative tests of the arc lamp in the laboratory as well as in actual service.

Arc lamps may be divided into three general classes, each having a characteristic of its own—the alternating enclosed arc, the direct current enclosed arc and the direct current open arc.

The alternating current arc presents a series of peculiar phenomena, especially in its effect in distorting the wave form of the generator. It is a well known fact that, if the distance between the carbon points of a direct current arc is fixed, any increase of current through the arc produces a drop in potential difference across the arc.

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

This evidently shows that an increase of current reduces the resistance of the arc by producing a relatively greater volume of conducting vapor within the arc itself. Applying this to the alternating current arc, we see that as the current wave reaches its maximum the resistance of the arc is at its minimum, and as the wave passes through the zero value, the resistance of the arc becomes much higher. This action is evidently very different from that of a simple ohmic resistance, and the effect upon the current wave is very marked. Much discussion has taken place regarding the effect in the arc, some contending that the higher current values produce a kind of thermo-electric counter electromotive force. The theory of increase in the volume of conducting vapor causing the reduction in resistance is, however, conceded to be the correct one. Professor Blondel, with Messrs. Duddell and Marchant, engineers of prominence, have studied alternating current arc by means of the oscillograph, and some of their results are shown by the following curves:



Curve 1 shows the variation in potential difference and current wave distortion when solid carbons are used.

Curve 2 shows the same effect with one cored and one solid carbon, and Curve 3 with two cored carbons.

These curves show a number of interesting effects.

Curve 1 shows a slight initial rise in the potential across the arc. This is probably due to the time required until the arc vapor has reached its full volume. Curves 2 and 3 show the effect of cored carbons in reducing the distortion of the current and electromotive force waves and increasing the power factor of the arc as follows:

Curve 1, power factor .74.

Curve 2, power factor .94.

Curve 3, power factor .99.

The vapor formed between the cored carbons has a much lower resistance than that formed between the solid carbons, not only because of greater volume of vapor, but because the conducting property of the vapor is greatly increased, due to the chemicals contained in the cores of the carbons. This property of the arc between cored carbons is of great advantage in alternating current arc lighting. First, because it permits a greater arc length, thereby increasing the useful illumination from the carbon points and because it reduces the amount of self-induction on the system necessary for a steady arc. The presence of self-induction is necessary in an alternating current system, as it has the fortunate tendency to reduce the distortion of the current wave. This may be briefly explained, as follows:

As the current lags behind the electromotive force, the zero point of the former is reached when the electromotive force is rising in value, and, as the arc resistance is highest at the zero point, the rising electromotive force tends to overcome this resistance and to cause a steadier flow of current. This distortion has a very important bearing upon the noise in the arc and upon the steadiness of the light.

The relative illumination of the direct and alternating current enclosed arcs and the direct current series open arcs has received much discussion, and much of this has been of a biased nature. The so-called 2000-candlepower arc light consuming 480 watts does not give 2000 candlepower, but gives considerably less than this. The average candlepower of the 480-watt open arc taken at an angle of 45 degrees rarely exceeds 1200 candlepower. The lamp usually rated as 1200 candlepower gives an average illumination at an angle of 45 degrees of about 700 candlepower. These maximum values, though of little use in considering commercial illumination, certainly show a discrepancy in the rating of lamps. Contracts for arc lighting should never be drawn up on the basis of nominal candlepower, but should specify the watt consumption of the arc, the grade of carbons and the kind of shades to be used.

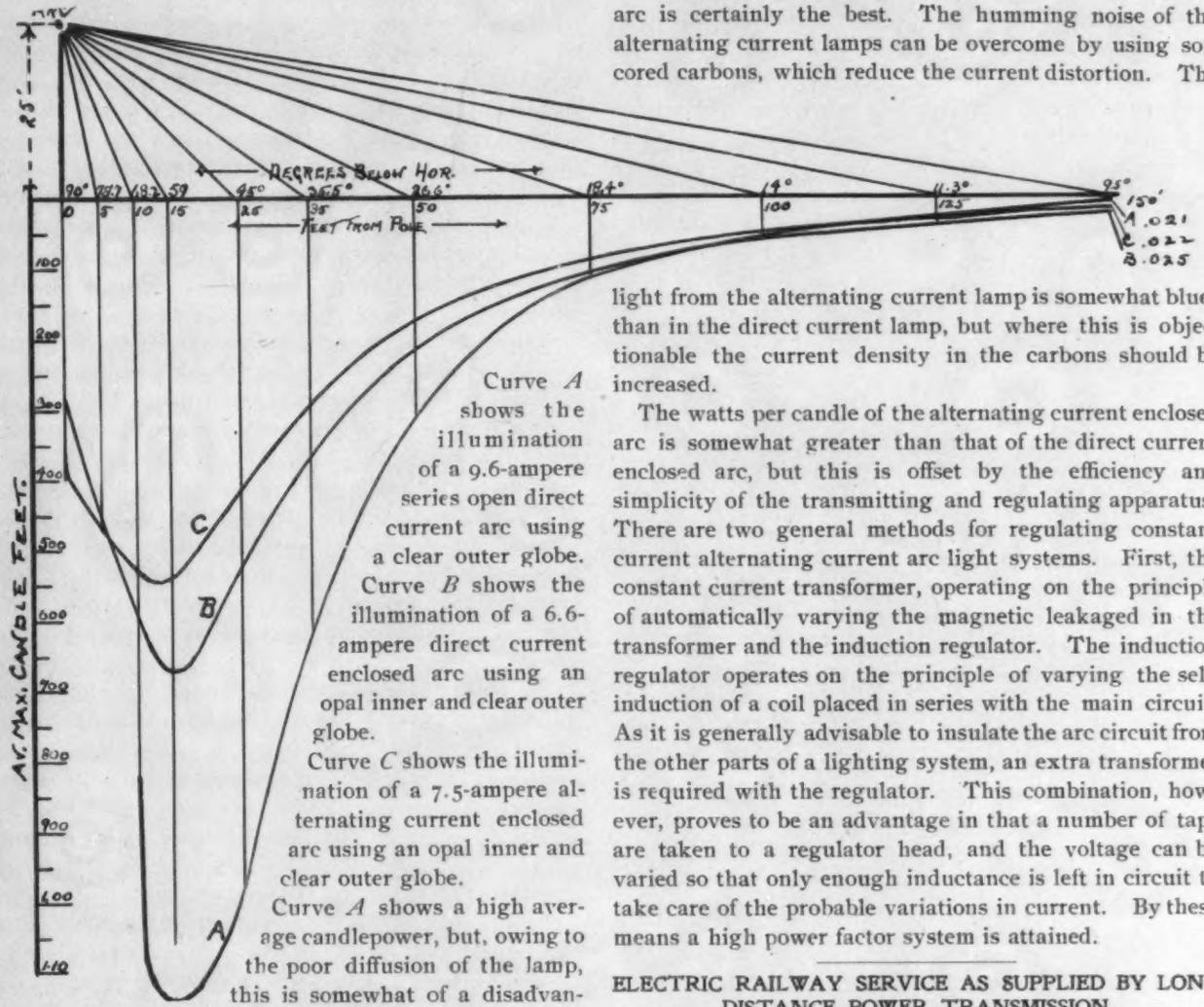
The character of illumination of the open arc differs greatly from that of the enclosed arc, owing to the difference in the character of the arcs themselves.

The illumination from the open arc is principally due to the intense heat of the positive carbon. Very little light comes from the vapor of the arc. The vapor coming in contact with the oxygen of the air forms a very intense chemical combination, and thereby decomposes the carbons very rapidly. This action produces the intense heat of the positive carbon from which practically all of the light is obtained. It is for this reason that the carbons should not be separated more than a certain distance, about one-eighth of an inch, because a greater separation would permit a freer combination between the arc vapor and the air, and would therefore produce a flame consuming the carbons in a short while. Owing to the closeness of the carbons much of the light in the open arc is lost, and that which is given out lacks good diffusion.

The enclosed arc is protected from the outer air by means of a clear or opal glass globe. This prevents the

intense action of the oxygen of the air with the arc vapor and permits the separation of the carbon points. A great part of the light of the enclosed arc comes from the vapor, and, as the carbon points are separated a considerable distance, effective and well diffused illumination is attained, especially is this the case with the alternating current enclosed arc, owing to the more uniform heating of the carbon tips.

The following curves, taken by W. D'a. Ryan and presented at the Ohio Electric Light Association, plainly shows the relative character of illumination of the enclosed and open arcs:



Curve *A* shows the illumination of a 9.6-ampere series open direct current arc using a clear outer globe.

Curve *B* shows the illumination of a 6.6-ampere direct current enclosed arc using an opal inner and clear outer globe.

Curve *C* shows the illumination of a 7.5-ampere alternating current enclosed arc using an opal inner and clear outer globe.

Curve *A* shows a high average candlepower, but, owing to the poor diffusion of the lamp, this is somewhat of a disadvantage. At an angle of about 70 degrees the light is very dim, and from this point to 90 degrees a circular shadow is formed on account of the crater being hidden by the lower carbon. At an angle of 45 degrees the light is very intense, and from this point to an angle of 9½ degrees the light falls off rather abruptly and is less at a distance of 150 feet than either of the enclosed arcs. The extremely brilliant light at the angle of 45 degrees is at great disadvantage in street lighting, owing to the fact that the pupil of the eye adjusts itself only to the brightest points, and the other objects surrounding these are but dimly seen. Good lighting can only be attained by proper diffusion, and this does not always depend upon the maximum average candlepower. In short, ideal illumination means that there will not be any one particular point very brilliant.

Curve *B* shows better diffusion and improved illumination at a distance.

Curve *C* shows less light at a distance than Curve *B*, but its diffusion excels that of Curve *B*.

In general the 7½-ampere alternating current enclosed lamp is considered equal to the 6.6-ampere enclosed direct current lamp.

In installing lamps for interior illumination the enclosed arc is certainly the best. The humming noise of the alternating current lamps can be overcome by using soft cored carbons, which reduce the current distortion. The light from the alternating current lamp is somewhat bluer than in the direct current lamp, but where this is objectionable the current density in the carbons should be increased.

The watts per candle of the alternating current enclosed arc is somewhat greater than that of the direct current enclosed arc, but this is offset by the efficiency and simplicity of the transmitting and regulating apparatus. There are two general methods for regulating constant current alternating current arc light systems. First, the constant current transformer, operating on the principle of automatically varying the magnetic leakaged in the transformer and the induction regulator. The induction regulator operates on the principle of varying the self-induction of a coil placed in series with the main circuit. As it is generally advisable to insulate the arc circuit from the other parts of a lighting system, an extra transformer is required with the regulator. This combination, however, proves to be an advantage in that a number of taps are taken to a regulator head, and the voltage can be varied so that only enough inductance is left in circuit to take care of the probable variations in current. By these means a high power factor system is attained.

ELECTRIC RAILWAY SERVICE AS SUPPLIED BY LONG DISTANCE POWER TRANSMISSION.*

BY ALLEN H. BABCOCK.

THE manner in which the electric street car put the old horse car out of business, and the tremendous growth of the industry, are within the recollection of all present today: but unless one has traveled within the past year or two through the more thickly settled communities, the present state of development will not be realized.

With the increased facilities for rapid transportation to the outskirts of the cities, it followed naturally that people

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of moderate means settled in the suburbs, and, as they moved outward, the electric lines reached out ahead of them, until adjacent towns became united by lines of fast suburban cars. The logical result is the interurban line that has gridironed the East and that inevitably must take its place in the West. Lines of thirty to fifty miles in length, operating thirty to forty ton cars under one hour headway, at maximum speed of from forty to seventy miles per hour, are scattered all over the Eastern and Middle Western states, and nearly all are in direct competition with steam lines in the passenger, mail, express, and light freight service.

So severe has this competition become that many of the larger steam roads now run electric interurban trains over their tracks, under the same operating rules that govern their steam service. For many reasons a service so operated will prove to be the most efficient and satisfactory in the ultimate. Only a man brought up in the steam railroad service can appreciate properly the necessities of a train service calling for speeds of sixty miles per hour, and the dangers inherent in the operation of a single car, light as compared with a locomotive, at these velocities. The layman may acquire some idea of what may happen in a collision or derailment when he remembers that a body moving at the rate of sixty miles per hour has stored up in it the same kinetic energy, and consequently can deliver the same blow, as if it fell from a height of 121 feet, disregarding the energy of the rotating parts, which, in the case of an electric car, would add about 10 per cent. Furthermore, the steam railroad man has spent a generation or two in improving his methods, and consequently is in the best position to tackle the new problem, different from the one he has solved only in that he carries his passengers on a locomotive that uses electricity instead of coal.

The best evidence in support of the position stated above is the success of the interurban lines running out of Los Angeles, every one of which is under the management and direction of men who have won their spurs in steam railway service. To my mind it is certain that these southern systems are merely the beginning of what is to be, and for this reason it seems to me proper to discuss the subject assigned me from this standpoint.

It is probable that lines built within the next few years will be equipped about as follows. In all towns the overhead trolley will be used—the third rail in the country. The track and roadbed will be of standard steam construction. The cars will weigh about thirty-five tons, equipped and loaded, and will be driven at least forty miles per hour. Under these conditions, at full speed the power input will be 94.5 kilowatts, and the current 189 amperes per car. Assuming an average rate of acceleration, the starting current at 400 volts at the car will be about 360 amperes, or nearly double the full speed running current. To supply this current to the car it must flow out through the power rail and back through the tracks. Assuming a 100-pound power rail of special composition to insure a low relative resistance, say 7.5 times that of copper of equal area of section, the resistance of the power rail, including bonding, will be 0.0347 ohms per mile. The track may be assumed to be of seventy-pound standard section, and since it is to be subjected to the usual track strains, the special composition will not be safe; hence its conductivity will be approximately one-tenth of that of copper, and its resistance, including bonding, will be 0.033 ohms per mile. The total resistance of the circuit will be close to 0.0677 ohms per mile, and the drop under the assumed load will be 12.8 volts per mile.

A total drop of 100 volts to a car at full speed is permissible, and 200 volts for a few minutes, as, for example, when two cars are meeting at a turn-out. It follows, therefore, that the rails will feed a car 7.8 miles from a substation, and that the substations may be located between fifteen and sixteen miles apart, provided the country is level, that the time card does not place more than two cars between adjacent substations, and that the cars do not accelerate from the turn-out at the same time.

These operating conditions are practical, since with the ordinary number of stops the forty miles per hour maximum will be cut down to a twenty-mile per hour schedule, which will carry a car from one substation to the next in forty-five minutes, and if one hour headway is assumed it will be easy to arrange the time card so that only two cars will be between any pair of substations.

Few locations can be found where there will be no grades, but with the exception of mountain roads the maximum gradient ought to be kept within 1.5 per cent. If the speed is dropped to thirty miles per hour on such a grade, the current input will be 250 amperes, provided the maximum drop of 100 volts is not exceeded, in which event the drop will be 16.6 volts per mile; hence there must be a substation within six miles of any point in the grade.

The substations will be located with reference to the freight and passenger business quite as much as with regard to the distribution of power to the line. Modern rotaries or motor generator sets demand but little immediate personal attention; hence the station attendant will act as station agent in the railway sense. His presence at all hours facilitates the shipment of perishable freight, especially butter, eggs, chickens, and milk.

A substation of this character will be a two-story structure, with living rooms on the second floor. The high tension leads will enter a tower toward the rear of the building, and the dynamo room will be on the side away from the road. In front will be the passenger waiting room and ticket office, with a freight and baggage room at one side.

For the size road considered, the electrical substation equipment will be two units of approximately 250 kilowatts capacity each on the direct current end, and the trend of development indicates the use of three-phase transformers of large capacity.

For roads of any importance, as trunk lines, a reserve plant is desirable. The reasons for this necessity are known to all of you better than to any other class of men, so they need not be stated. Whether this reserve will be

in the shape of a battery, or of a prime mover (either a steam or a gas engine), will depend largely upon the local conditions. Our latest information on the subject leads us to hope for a gas engine of sufficient size and reliability to be of practical use in this field. If these hopes are realized an almost ideal reserve plant can be installed; viz., a gas producer to utilize crude oil, with a holder large enough to contain a supply for say an hour's run, and a store of compressed air by means of which to start the engine. Such a reserve would make unlikely any serious stoppage of the cars. To my mind it is not probable that a battery would be installed, since to be of any practical use to remove the peaks or to act as a reserve for any length of time it would cost as much as a duplicate station plant, and in case of a really serious shutdown to the transmission line its usefulness soon would come to an end. From observations made last summer on many roads of this character, it is my opinion that, in the great majority of cases, to put in a battery to smooth down the peaks would be an unwise expenditure of money, or, stating it another way, it seems to me that the same amount invested in a reliable gas engine plant would bring a greater return. The peaks in a load of this kind are not great in their effect on the system as a whole, while the maintenance of a time card is of the utmost importance.

The use of the third rail instead of a trolley wire is made probable by a variety of causes, but since this matter in no way affects the transmission side of the line, it need not be gone into in detail. This much may be said, however. Assuming that poles are necessary for the high tension line and for train dispatching purposes, so that their cost would not be chargeable against the overhead system, a third rail can be installed for less than 90 per cent. of the cost of a single track bracket overhead system of equal conductivity.

A glance at the map of the State will show two facts that indicate very plainly the future relation of long distance transmission to the electric railway of the future. If the experience of the older communities is any guide to prophesy, we may expect to see interurban railways developed along lines roughly parallel to the existing steam lines; that is to say, trunk lines will be run along the axis of the State with branches perpendicular thereto for distribution purposes. Of necessity the power must be developed along the slopes of the Sierras, and transmitted to the centers of population, which normally will be located in the valleys. In consequence, the transmission lines will intersect the main railway lines at more or less frequent intervals, and will parallel the branch lines.

It is evident that the operating conditions of a railway service of the kind indicated above do not present any extraordinary difficulties to the transmission engineer, and since, over a large system, the loads will be fairly well equalized, the transmission companies can afford to make rates that will be certain to capture the business.

In the ten minutes allotted to me a critical review of the situation is an obvious impossibility. It is expected that the foregoing brief notes will be regarded simply as an opening of the discussion.

LOCAL DISTRIBUTION OF TRANSMITTED POWER.*

BY GEORGE C. HOLBERTON.

IT has been suggested that I read a paper on the above subject, with the remark that the reading should occupy not to exceed ten minutes. After giving this subject careful consideration, I discovered that to even touch lightly on the details of a subject of such extent would require several volumes, and probably occupy two or three weeks time to read the same. In place, therefore, of entering into the details of such a subject, I will, with your kind permission, divide the matter in hand into several headings, calling your attention to the lines along which we must work in order to accomplish the best results in the matter of the distribution of our transmitted power.

Starting in to divide this subject from the secondaries of the transmission transformers, the first thing we encounter is the regulator heads. In the case of a great many regulator heads installed on the coast in the past, the heads have consisted of a finger passing through various contacts in the open air, such contacts being connected to various taps on the secondaries of the transformers. To prevent the excessive sparking at the moment that the finger passes from one contact to another, the makers have in some cases installed a choke coil connected across the gaps, in other cases a choke coil in a flat circular form has been fastened to a divided finger so arranged that when the forward half of the finger enters the next contact, the other half has not yet left the contact from which the finger is moving.

REGULATOR HEADS.

When the finger has arrived at its proper position in the next contact, the contact itself short-circuits the choke coil. All of these arrangements are very ingenious, but I do not think we can hope to get the best results until these contacts are immersed in oil. As a rule, the whole construction of the regulator head has been over crowded and hard to go at without shutting down, so that it has been difficult to keep these lubricated and clean. I therefore think, as a general rule, it is cheaper in the end to utilize some form of head which is immersed in oil. While on the subject of regulator heads, there seems to be a chance for considerable discussion as to the true purpose of these heads. The writer, personally, does not consider that the regulator head, as built at present, is at all suitable for the purpose of taking care of the small variations in voltage, caused by changes in local conditions, but rather for the purpose of delivering a practically constant voltage under changing conditions on the high tension transmissions lines, that is to say, the high tension line is figured on the basis of a certain load, both the character and amount of which will probably change greatly after the line is installed, causing more or less drop than was at first figured on.

To overcome such permanent changes as this, the regulator head will answer very well, but I do not think the practice of using these heads to overcome local

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

fluctuations is a good one, although I have noticed this is done in several of the smaller plants. Other suggestions as to a better means will be taken up under another heading.

Passing from the secondaries of the transformer, we now come to the switchboard. Taking the average case that we find on the coast, I believe it is well to install, close to the high tension transformers, a receiving and seggregating panel. The purpose of this panel is to measure the total input and also to distribute same to the various feeder panels. This panel should contain a voltmeter, preferably a recording one, also ammeters and integrating wattmeters. In the case of very small stations, where it is necessary to curtail the initial expenses, the integrating wattmeters on the receiving panel may be omitted. You will notice that I suggest ammeters on the panels and not indicating wattmeters. Where it is desirable to know the input from, or output of, large generators or transformers, I think it is advisable to consider such output in volt-amperes rather than in watts, as the maximum load is more a question of amperes than anything else when considering loads of low power factors.

RECEIVING PANELS.

In addition to the instruments referred to, the panel should contain oil switches for cutting off the current from the various sets of panels, such as lighting panels, power panels, and street light panels. In the smaller stations it would only be necessary to have two switches, one for the general light and power business, and the other for the street lights. It seems that the general tendency is toward the use of constant current transformers for street lighting either by means of arc lamps or series incandescent lamps, or a combination of both. By having the street light service connected to an automatic switch, it will not only provide against trouble in either transformers or lines, but will also dispense with the all-night station attendant, as the tripping coil of this switch can be connected to a clock work arranged to open the switch at the time the street lights are to be shut off.

The character of the distributing boards must necessarily vary with local conditions, but should be so constructed as to show the total output at any time, and also the output from month to month. This is very necessary that the company may know the money they are receiving from the various classes of business. The sum of all the wattmeter readings on the distributing boards will serve as a check on the wattmeters on the receiving panels. But if for the sake of economy one or the other of these integrating wattmeters must be omitted, I would strongly recommend omitting the wattmeters on the receiving panel. The small meters will probably record more accurately and will also seggregate the amount of current consumed in the different branches of the business. From past experience, the writer is satisfied that all instruments should be operated by means of current and potential transformers, the secondaries of which are grounded. This increases slightly the cost of the instruments, and may even effect their accuracy to a small extent, but as a means of protection to both the operator and the instruments, they are well worth their additional cost, and any sacrifice that may be made in the matter of accuracy.

DISTRIBUTING BOARD.

Without leaving the switchboard, the next thing that we encounter is that of the regulation of the various services. On this subject the writer has had considerable experience, having tried a number of devices to accomplish these with varying success. As to the regulation in the case of street lighting, where this is done by means of the series system the transformers themselves will take care of any ordinary fluctuations.

REGULATORS.

In the matter of the general supply of light and power, means must be provided to increase the pressure at the station, as the load increases; and also take care of any variations in voltage due to character of the current delivered. After experimenting with several types, the writer has found the greatest satisfaction from an automatic regulator, in which the movements of the parts is accomplished by means of an electric motor operated from a voltmeter by means of relays. This voltmeter may be connected to the center of distribution by means of return pressure wires or may be connected to some form of compensating device which will accomplish almost the same results without the use of the pressure wires. As an illustration of what may be done in this way, I refer to pressure charts, shown here, from the same circuit. In one case the regulator was hand operated, and in the other case automatic, as above described. You will see at a glance the advantage of the automatic regulator, to say nothing of the saving in labor. The one objection to this method is its first cost. The regulator in question has a capacity of 100 amperes, and 200 volts boost.

There is still another form of regulator which will shortly be placed upon the market, which I think will be an improvement over the one from which these charts were taken. In this device the regulation of voltage is effected by a specially built transformer having a fixed primary and moveable secondary with an open magnetic circuit. It is so constructed that the secondary winding may be shifted between positions of maximum and minimum magnetic strength, or it can be moved entirely out of the magnetic field. When in the latter position its connections relative to the primary may be reserved so that the total induced secondary potential may be either added to or subtracted from the potential of the circuit. The movement of the secondary coil is effected by a pneumatic power device which is controlled by a potential balance, or by a relay that is operated therefrom in a manner similiar to that already described in connection with other feeder regulators. The advantages of this device consist in its having no revolving machinery and no contacts continually making and breaking connections while heavy currents are flowing. It is, however, at present in a comparatively experimental stage, but

will probably be developed into a very useful piece of apparatus.

DISTRIBUTING SYSTEM.

The general character of the distributing system, whether single-phase, three-phase, or two-phase, together with the voltage, must depend upon local conditions, and be governed accordingly. Regarding the secondary portion of the distributing system, there are, however, several features which I think could be used to great advantage in the present system In the first place a glance at the distribution in many of the smaller towns will show you a vastly larger number of transformers than are necessary. As a general thing, it is much better to keep down the number of small transformers, even in the case of cheap water power. The regulation of the large transformers is much better than the smaller ones. Also the capacity necessary in the case of large transformers is much less than in the case of individual transformers. In the case of individual transformers, it is necessary to have a transformer capacity approximately equal to the number of lights installed, whereas in the case of large transformers, you can install on a meter basis from five to ten times the number of lights that the transformer is rated for. In the case of flat rate consumers, the ratio must be greatly reduced. Another point in connection with these transformers is the question of size. It would seem to me to be better not to purchase so many different sizes of transformers, but rather to keep to a few standard sizes even if they are installed a trifle larger than necessary. I believe there is great room for improvement along the lines of increased voltage on the secondaries.

I notice that even now transformers are being built and purchased with 1000- and 2000-volt primaries, and 50- and 100-volt secondaries. There are practically no companies operating at fifty-volt secondaries, and I think very few at 1000-volt primaries. Would it not be better, therefore, to purchase our transformers having primaries of 4000 and 2000 volts and secondaries of 400 and 200? One of the large expenses of the company is that of copper, the amount of which can only be cut down by limiting the extent of the secondaries, fed from one transformer, or by increasing the voltage. The first method means diminish transformer capacity and inferior regulation. In Oakland we have been installing in the outlying districts nothing but 200-volt services for about three years with splendid results. At first we had trouble obtaining supplies for these circuits, but now we have no trouble whatever. Night lamps, sewing machine motors, fan motors, and in fact everything but arc lamps can be purchased wound for 200 volts. On account of the trouble with 200-volt arc lamps, we are still using a 200-volt three-wire network in the heart of our business district. In the residence district we use a 400-volt three-wire system, using 200-volt two-wire services. The writer read a paper on this subject before the Pacific Coast Gas Association about two years ago, and would add that we have worked along the lines of that paper for over two years with great success, having now about 1500 such two-wire 200-volt services.

Passing from the lines to the consumers premises, we encounter the subject of meters and their connections. This is probably one of the most important branches of the company's business, and in general should receive many times the attention which it does. Remember that the meter is responsible for your revenue, and upon its accuracy depends your gross receipts. Each company should bear this in mind and pay strict attention to the initial installation and the care of the meters.

METERS AND CONNECTIONS.

Meters are rarely received from a factory in perfect condition, and must be adjusted, and even if they were so received, would probably be out by the time they are transported to and installed in the consumers premises. No meter should be set up and left without testing to see that it is correct. In the large companies, this should be done by having the meter tester follow up each installation. In the smaller companies this can be done by the man who places the meter. After the meter is in place it should be visited periodically, the interval between visits depending upon the size and character of the installation. The more current the meter is registering, the more often should it be visited. In addition to the effect of this upon your revenues, it has a great moral effect on the customer, giving him much more faith in the accuracy of the meter. Another subject in this connection is the character of the meter installation. Far too little thought is given to the proper place in which to install a meter, it being a common sight to see an electric meter statement taker going his rounds with a step ladder.

Companies should insist upon the local wiremen making provision for the meter in such places as may be approved by the company. As to the meter itself, there seem to be many varying opinions as to which meters are best. For alternating work, the writer prefers some form of induction meter rather than a motor type of meter having a commutator. Also the meter should have the lightest possible moving elements, and the maximum amount of torque. This increases the life of the jewels and aids in registration on extremely light loads. All meters should be provided with some form of device to prevent creeping, which device must not interfere with its accuracy on light loads. I believe it is also better to provide some means of adjusting the meter for slightly increased friction, rather than to attempt to eliminate friction entirely, as it is almost impossible to to do this. This question—the selection, installation and care of the meters—is a large subject in itself, and I believe it would be of great value to the association if some one were to write a paper on this subject.

WIRING.

Passing from the meter, we come to the consumers' wiring. The one point which I wish to make in this connection is the question of the inspection of the consumers' wiring. In large cities there is generally a city official whose duty it is to take care of this subject, but in the smaller cities and towns no such provision is made. I believe that every company, where there is no city inspec-

tor, should do this work, though it be at their own expense, and that they should refuse, absolutely, to connect to any wiring unless it complies with the rules of the National Board of Fire Underwriters. This practice has been in vogue for over two years with the Oakland Gas Company, and we do not now have a one-hundredth part of the complaints with our 200-volt services that we formerly had with the old poorly installed fifty-volt services. At first the wiremen objected strongly to our stand on this subject, but of late we have had no complaint. Needless to say, it is greatly appreciated by our consumers and by the fire underwriters.

This is an important subject, and deserves a great deal of attention. Most of the work along this line has to be educational. It is surprising how little the consumer seems to know about the kind of lamps he should use, often ordering lamps entirely unsuitable for his purpose, and for the service which he receives. I believe there is only one solution of this subject, and that is, that in some way the lighting company supplies all the lamps used upon its system. If this cannot be done on the basis of the superiority of the lamp furnished by the lighting company, then it must be done in some other way.

LAMPS.

Personally, the writer believes in absolutely free renewals of the lamps supplied by the company. There are, however, a great many arguments both for and against this practice, but if free renewals cannot be adopted, then I believe in some form of compromise. Lamps not burned out, but blackened, could be exchanged for new ones at much less than the retail price of the lamps in order to encourage the consumer to renew his lamps before they burn out; or lamps could be sold by the company at a very low price, which would shut out all other lamps except those furnished by the company. I hope there will be considerable discussion on this subject, as I believe it is a very interesting and important one. The subject of the lamp would seem to bring us to the end of our distributing system, but it don't. One of the most important parts of the distributing system lies beyond the lamp. I refer to the consumer himself. However, it is hardly the province of the technical end of the business to discuss this subject, the business manager and his assistants coming into closer contact with the customer than the engineering department of the company.

I would feel, however, that if I stop the paper without referring to the consumer I would be guilty of failing to mention one of the most important ends of the distributing system, and one which requires an immense amount of careful thought, and which is probably the hardest portion to handle.

I trust that the foregoing remarks will invite your discussion along the lines indicated.

THE ELECTRIC AUTOMOBILE AS AN INCOME PRODUCER FOR CENTRAL STATIONS.*

BY A. E. BROOKE RIDLEY

THE advent of the automobile has been so recent that its progress and possibilities seem to have, as far as the Pacific Coast is concerned, entirely escaped the notice of central station managers. And yet, I have no hesitation in saying that within a very few years most of the commercial and also the passenger transportation now carried on by horse traction will be carried on by automobiles in preference. In this event it will be readily seen how large an income factor automobiles will prove in the future. The profit to the central station from any specified service depends upon three conditions, namely:

1. Quantity of current consumed.
2. The time at which the current will be required.
3. The character of the load.

With regard to the first point, viz , the quantity of current required. A light electric runabout will consume not less than fifteen amperes on the four-hour rating, and will run about forty miles on one charge. A 5000-pound truck will require a battery capacity of fifty amperes on the same rating. The mileage per charge at the present time being between twenty-five and thirty-five miles.

There is certainly no city or town so small that it does not use at least fifty vehicles of some sort; and to say that 50 per cent. could be replaced by automobiles is making a conservative estimate. These vehicles could comprise buggies, farm wagons, tradesmen's carts, delivery wagons, ambulances and express, freight or passenger wagons.

Allowing a daily average of twenty amperes at 125 volts for these vehicles on a four-hour charge would mean an output of 250,000 watts, which at 4 cents per kilowatt represents an income of $10.00 per day.

As the charging of batteries of electric vehicles follows the standard rules for charging stationary batteries, the charge generally could be tapered off and spread over seven or eight hours. This length of charge, although necessary to obtain a full mileage, is by no means essential, as half charges can be put in in a couple of hours without injury to the battery.

With regard to the second point—the time at which the current will be required—the conditions of service of automobiles will permit of their being charged at periods of light central station load when the station has plenty of power which central station managers are unable to use; and except on emergencies, there will be seldom any reason to charge many automobiles between the hours of five and ten o'clock at night. The load conditions, therefore, are what the central station manager is trying his best to obtain, and represent a factor of almost clear profit, especially when the station is operated by a water power transmission plant with free water.

The third point, viz., the character of the load. The

*A paper presented to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, June 16-17, 1903.

character of the load is absolutely ideal, being a perfectly regular and steady storage battery load without fluctuations. It has the further advantage of steadying the day voltage, the irregularity of which frequently gives serious fluctuations in the lighting load in consequence of the power factor being so greatly in excess of the lighting factor.

Regarding the expense of operating automobiles, an impression prevails that automobiles are an expensive luxury, and while this has been so in the past, it has been because machines have been put on the market quite inadequate to the work they were called upon to perform.

There is no more reason for automobiles to break down than for horses and carriages. On the other hand there is far less reason, and the cost of operation per mile of travel should be less. The speed is greater than that of the horse, the distance far in excess, the reliability and convenience far greater.

The automobile is unaffected by the heat of summer or the cold of winter, may be urged to its limit up hill and with safety driven fast down hill; in fact there is no service that the horse is at present performing that cannot be better done, even in the present early stage of the industry, by an automobile.

There is also a widespread impression that an electric automobile is incapable of a greater speed than ten or twelve miles per hour. This is entirely erroneous, as there is no more limit to the speed of this machine than to that of one operated by steam or gasoline, the speed being simply a question of power and gearing.

Very few high speed electric automobiles are at the present time on the market, simply because the manufacturers are so busy trying to keep up with the demand for their present standard types that they have no time to bring out new designs.

Up to the present time I know of no central station manager who has given this matter any serious consideration or made any attempt to assist in the development of the industry; but I feel assured that if the companies would install motor converters and operate wagons of their own, their example would be followed by many who are now deterred by the inability to secure direct current suitable for charging their machines.

Several automobiles are now being used as service wagons by the superintendents of the electric light plants in the Eastern cities, and they are giving entire satisfaction. There is no reason why the success of an electric automobile in the East for carriage, hack, delivery wagon and truck service should not be repeated here.

The sooner the central station managers investigate this matter seriously, the sooner they will obtain a valuable source of income, besides conferring a benefit in advancing a new and growing industry.

BULLOCK STOCK INCREASE.

The stockholders of the Bullock Electric Company, Cincinnati, Ohio, have voted to increase the 6 per cent. preferred stock from $1,000,000 to $1,500,000. The money thus derived is to be used for the purpose of erecting more buildings and carrying a larger stock of material on hand.

TANGENTIAL WATER WHEELS UNDER 1912 FEET EFFECTIVE HEAD.

BY W. A. DOBLE.

RECENT development in hydraulic practice on the Pacific Coast has been in the tendency of the utilization of higher heads. In the minds of a number of engineers the question has arisen as to the wisdom of developing these high heads, utilizing the totality of fall in one station, as against dividing the fall up and passing the water through two or more stations in series, in this way utilizing the same water under lower heads in two or more power plants.

The Edison Electric Company, of Los Angeles, had this problem to consider when it was proposed by them to install their new power plant, which has been known as Mill Creek No. 3, it being located in the Mill Creek Canyon, near Redlands, Cal., the effective head on this plant being 1912 feet. After carefully considering the matter the Edison company decided that it would be better engineering to utilize the total available head in one power station. They also concluded that, as they had several other power plants to build, this would be an excellent opportunity to test the relative merits of the different water wheels on the market.

The plant to be installed by them was to consist of four water wheel generating units of 750 kilowatts each, designed for a 25 per cent. overload at a turning speed of 430 revolutions per minute. They therefore decided to install at first but two units, the balance of the plant to be placed with the engineering firm furnishing the most efficient and satisfactory wheel unit. Accordingly they placed an order for one unit with the Pelton Water Wheel Company, of San Francisco, the order for the second unit being placed with the Abner Doble Company, San Francisco, makers of the ellipsoidal tangential water wheel, at the same time taking an option from each firm for two additional wheel units, with the agreement that the order for the additional wheel units would be placed with the engineering firm furnishing the wheel unit of the best engineering design, workmanship, efficiency and giving the most satisfactory results when in operation.

The initial wheel units were installed and after being in operation for several months were tested. It is interesting to note that, based on the results secured from these two wheel units, the power company exercised their option, placing the order for the balance of the wheel units with the Abner Doble Company on account of the high efficiency shown by their wheel, its capacity to carry a very heavy overload and the maintenance of this high efficiency over a wide range of load. The Doble wheel unit at loads from one-half load to 25 per cent. overload, showed an efficiency on the preliminary tests of from 80 per cent. to 84 per cent. The generators in this plant were furnished by the General Electric Company. This installation is of value in confirming the wisdom of the power company in utilizing their total head in a single station, as against dividing it up over several stations, as has been carried out by several of the other power companies.

The nozzle used on this machine is of the Doble patented needle regulating type, which gives an exceedingly favorable efficiency curve with variable load, the water consumption of the unit being almost strictly proportional to the power output of the generator. Another important point demonstrated by this installation is that the efficiency to be secured from tangential wheels under these very high heads is exceedingly favorable, clearly demonstrating that it is better engineering to utilize the total available power value in one station than to divide it up into two or more, excepting in most exceptional cases where other conditions may exist, such as, for instance, excessive length of pipe line or reservoir and storage facilities.

These tests make a very interesting comparison with the work of one of the famous Swiss builders in the Vouvry plant, where the efficiency secured was 56 per cent.

COPPER WIRE FOR ENGLAND.

The John A. Roebling's Sons Company, 117-119 Liberty Street, New York, is shipping considerable copper wire to England.

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SPECIAL NOTICE.

The attention of our readers and advertisers is called to the removal of the office of "The Journal" from 144 Union Square Avenue to Room 302 Rialto Building, San Francisco.

ALL communications, whether to the editor or to the manager, should be directed to the JOURNAL OF ELECTRICITY PUBLISHING COMPANY at the new address.

EDITORIAL.

SEVENTH ANNUAL CONVENTION.

In this number will be found several of the papers read before the Seventh Annual Convention of the Pacific Coast Electric Transmission Association, which convened at the Hotel Rafael, San Rafael, June 16th, and adjourned for an outing on Mt. Tamalpais June 17th, subsequently enjoying a visit to the new power house of the United Railroads, of San Francisco.

The itinerary was as follows:

Attendants to the Seventh Annual Convention of the Pacific Coast Electric Transmission Association will take the Sausalito Ferry leaving the foot of Market Street, San Francisco, at 9:30 a. m. on Tuesday, June 16th, purchasing round-trip tickets for San Rafael.

In session from 11 a. m. to 12:30 p. m.

At 2 p. m. the session will reconvene and continue until 4:30 p. m., when the regular members will go into executive session for the election of officers to serve during the ensuing year and the transaction of such other business as may be necessary. At 6 p. m. dinner will be served in the private dining room. At 8 p. m. Mr. George J. Henry, Jr., chief engineer of the Pelton Water Wheel Company, will lecture on "Buckets for Tangential Water Wheels," which will be illustrated with stereopticon slides. At 9:30 a. m., Wednesday, the Association is to become the guest of the North Shore Railroad for a trip of inspection over the new third rail system, as far as completed on the Mill Valley section, after which guests will ascend Mt. Tamalpais for luncheon, and on returning to San Francisco the new power house of the United Railroads will be visited upon the invitation of the General Electric Company.

The papers read were:

"After the Ions—What?" by Professor Alexander G. McAdie.

"Electric Automobiles as Income Producers to Central Stations," by A. E. Brooke Ridley.

"Single Phase Motors on Polyphase Systems," by H. A. Bullard.

"The Influence of Periodicity on Line Capacity," by W. F. Lamme.

"Alternating Current and Direct Current Arcs in Street Lighting Service," by P. C. Butte.

"Electric Railway Service as Supplied by Long Distance Power Transmission," by A. H. Babcock.

"The Engineering Organization of a Transmission Company," by L. M. Hancock.

"Buckets for Tangential Water Wheels," by Geo. J. Henry, Jr.

"Electric Power for Mining Purposes," by George Scarfe.

"The Local Distribution of Polyphase Currents," by Geo. C. Holberton.

This convention was possibly the most interesting ever held by the Pacific Coast Electric Transmission Association, and served to emphasize more than ever the necessity of enlarging the membership and gathering within its confines as many of the active participants in electrical development as can be induced to join the charmed circle.

The "man behind the guns" is recognized as a most important factor in winning a battle, which truism has been more or less accentuated by reports of admirals Dewey, Schley and Sampson in their official papers describing the engagements of the Spanish-American conflict. The fact is also recognized that the man in the power house and the superintendent of the central station are also most important factors in the development of a plant, and that their work brings into play an entire set of experiences that may escape the astute superintendent, the general manager and the officers of the corporation.

In touch with the growing spirit of the times of combining within a closer bond the interests of employer and employee—of meeting on a scale of equality and sociability at certain stated times when the business bars of the capitalist and wage earner may be cast aside—the trend of the Pacific Coast Electric Transmission Association seems to be toward a complete membership of all those who are sincerely engaged in the general upbuilding of the electrical business.

The membership at the present time is limited—in fact has consisted in great part of corporate membership. A movement is now on foot to include a large individual number of practical workers, which, if accomplished, cannot but result in a corresponding benefit to the Western electrical field, and, consequently, to the development of the industry at large.

The convention was notable from many points, two of which were of extraordinary interest. The paper read by Mr. McAdie and the resulting discussion brought in

the calcium light of immediate attention a factor which within a short time may change the whole system of electrical research and do away with much of the cumbersome but necessary systems of machinery in vogue at the present time. Mr. McAdie's closing paragraph is pregnant with forecast, and it is pardonable to emphasize it with a reproduction here.

Who shall say that it may not be possible to do away with much of the intermediate apparatus now required in furnishing light. At present we are like the singer who runs the scale every time a certain note is desired. There must be some way of utilizing more directly radiant energy than by damming water to furnish power to run dynamos to furnish current to be distributed via mains and insulators to render incandescent a filament of carbon.

The exhibit of Mr. Henry formed one of the sensational episodes of the convention, showing as it did in a plate glass frame the action of water on wheels of different types in action. From every standpoint Mr. Henry's exhibit was extremely interesting, and his paper pertaining to the efficiency of water wheels with which the exhibition dealt will be one of the picturesque features of the next issue of THE JOURNAL.

The expense incurred by Mr. Henry in his illustrated lecture and tangential exhibit must of necessity have been very heavy, which goes to prove how seriously the influence of the Pacific Coast Electric Transmission Association is considered and how much interest its members take in making each convention surpass in interest that of its predecessors—factors that go far towards upbuilding the organization and guaranteeing its perpetuity.

Another feature of the Convention which should not be lost sight of was the illumination of the hall by the Nernst lamps. These lamps were contributed by the Kilbourne-Clarke Company, of San Francisco, to illustrate their superiority over the ordinary incandescent light. The general satisfaction expressed by the members fully demonstrated the claims made by the manufacturers of this new illuminant.

ELECTION OF OFFICERS.

At the business meeting of the Pacific Coast Electrical Transmission Association, held on the afternoon of June 16th, the following officers were elected to serve for the year ending June 21, 1904: President, H. H. Noble, Northern California Power Company; vice-president, H. H. Sinclair, Edison Electric Company, Los Angeles; treasurer, F. M. Ray, California Gas and Electrical Corporation, San Francisco; secretary, Geo. P. Low, JOURNAL OF ELECTRICITY, POWER AND GAS, San Francisco; C. W. Hutton, Sacramento, editor "Wrinkle" department.

In addition to the foregoing, John A. Britton, Oakland Gas, Light and Heat Company, and Rudolph Van Norden, of the Central California Electric Company, were made directors.

One other important feature of the meeting was the appointment of a committee of five to report on a standard system of local polyphase distribution, which was the direct result of the paper read at the meeting by Mr. Holberton.

RADIUM AND RADIO-ACTIVE SUBSTANCES.

At the meeting of the Transmission Association there was manifested a general desire for information concerning radium. More particularly the desire was for information as to the possible future use of these radio-active substances as independent sources of illumination. There are very few who are conversant with the work of scientific investigators during the past four years who do not believe that many substances will ultimately be found capable of giving out light. There is a difference between phosphorescence and radio-activity in that the glow of phosphorus is due to a slow oxidation, while the radio activity appears to exist even when there has been no previous exposure to bright light.

Professor J. J. Thomson, in *Harper's Monthly Magazine* for January, 1903, and for September, 1901, describes the search made by scientific men the world over during the past five years on Roentgen rays, Cathode rays and Becquerel rays. The last named being in fact a mixture of the other two.

Professor and Madam Curie, investigating uranium, were able to extract from pitch blend polonium. Subsequently radium was extracted by M Benent and actinium by De Bierne. The Curies have purified radium and investigated its properties.

In an article in the *Monthly Weather Review* for December, 1902, a number of facts relative to radium are quoted from Professor Thomson's extended memoir prepared for the "Britannica."

In its purest condition it exceeds uranium a hundred thousand fold in its radio-activity. The velocity of the rays emitted is said to be 120,000 miles per second. * * * It is self-luminous, shining with a bluish light. * * * Like Roentgen rays it makes a sensitive screen phosphoresce. * * * It can make other substances radio-active. Gases become conductors of electricity under its influence. * * * The induced radio-activity is very much increased if the substance is negatively electrified while being acted on by the emanation.

ELEVENTH ANNUAL MEETING PACIFIC COAST GAS ASSOCIATION.

THE Eleventh Annual Meeting of the Pacific Coast Gas Association will be held in San Francisco, Cal., at the offices of the Pacific Gas Improvement Company, 455 Sutter Street, on Tuesday, Wednesday and Thursday, July 21st, 22d and 23d, 1903. The following papers will be read:

"President's Address," by M. C. Osborn, San Francisco, Cal.

"Wrought Pipe," by Franklin Riffle, San Francisco, Cal.

"High Pressure Gas Distribution," by John A. Britton, Oakland, Cal.

"Liquid Air—Its Application to the Gas Industry," by Professor G. A. Bobrick, Los Angeles, Cal.

"The Oil Industry of California from a Commercial Standpoint," by Dr. C. T. Deane, San Francisco, Cal.

"Our Customers and Their Complaints," by D. Decker, Santa Rosa, Cal.

A paper (subject to be announced later), by L. P. Lowe, San Francisco, Cal.

In addition to the above papers there will probably be contributions by at least two of the members on "short topics" of interest to the fraternity.

Arrangements have been made for a "Popular Lecture on Liquid Air," by Professor Bobrick, which will be given at the regular

meeting place, Tuesday evening, July 21, 1903. The lecture will be accompanied by experiments. It is the intention to make this lecture essentially a popular one, and members are cordially invited to bring their friends, including ladies. Informality will be the order of the evening.

Wednesday evening, July 22d, will be the occasion of the annual banquet, to be held at Delmonico's, at which members only will be present.

On Thursday, July 23d, an all-day trolley car ride will be given, and members will be conveyed by special cars to many points of scenic and historic interest in San Francisco and thereabouts. An opportunity will also be afforded them to inspect at least one of the large power plants in the great metropolis of the Pacific. Luncheon will be served at the Cliff House, and ample time will be allowed for a visit to Sutro Baths (the largest in the world) or a stroll upon the beach. Following the usual custom, ladies will be welcome on the outing.

Through the courtesy of the Mechanics' Institute, arrangements have been made whereby the privileges of the Mechanics' Library, 33 Post Street, are granted to all members of the Pacific Coast Gas Association during the period of its Eleventh Annual Meeting. J. M. Cummings, secretary, acting for the Institute, extends to members a cordial invitation to make free use of the books and rooms of the library, and will take pleasure in giving them any information or assisting them in any way in the use of the library. It is hoped that members will show their appreciation by availing themselves of these privileges. No entrance tickets are required, but members will kindly wear the convention badge as a means of identification.

Members are strongly urged to lend their individual support to the "Wrinkle Department," George H. Colquhoun, Fresno, Cal., editor; the "Experience Department," R. P. Valentine, of Sacramento, Cal., editor; the "Novelty Department," George H. Hollidge, Merced, Cal., committee in charge.

The "Wrinkle" and "Experience Departments" depend for their very existence upon the willingness of the members to contribute, and are an index to the "lag" or "lead" of the association as a whole. Please remember this and help to maintain the standard.

The "Novelty Department" is, in truth, a novelty this year. In it we hope to find samples or models of all the good things manufactured during the past year for which a "gas man" has use. If you know of any, communicate immediately with Mr. Hollidge.

An effort is being made this year to give the "Question Box" the attention which it merits, and to this end a special communication has been issued on the subject. An immediate reply thereto is requested.

Secretary J. B. Grimwood will be glad to meet members and furnish information at any time prior to the meeting at 628 Rialto Building, San Francisco, Cal.

A WELL DESERVED DISTINCTION.

Professor Albert Van der Naillen of this city has been created Chevalier de l'Ordre de Leopold by the King of the Belgians by royal decree of May 6th. This honor conferred upon Professor Van der Naillen, in the language of the communication addressed to him, was because "of having carried on for a half a century, and in a most honorable manner, the profession of civil engineer, and during all that period of time having fostered commercial relations between the United States and Belgium, to the advantage of both countries, and last, but not least, of having created and successfully presided over for more than a quarter of a century, a technical institution of the first order."

The jeweled insignia that accompanied the notice of the honor conferred, will be worn by Professor Van der Naillen on all important occasions. In every day life a scarlet ribbon in his button-hole will tend to remind the Professor of the distinction he so eminently deserves.

THE DESIGN OF TANGENTIAL WATER WHEELS.*

BY GEORGE J. HENRY JR.

MINES are usually located in comparatively inaccessible places, where freight rates are high, resulting in expensive fuel. The surface workings seldom permit of locating the power in one main unit, or if steam, even in one boiler plant. The efficiencies of steam engines that are used are not therefore so high as might be desired. The erratic nature of the power curve due to hoisting, or the use of a varying number of drills, necessitating the firing for quite or nearly the peak load, further increases the cost per horsepower delivered from the engines. There are probably many more steam engines representing an outlay of $150 and more per delivered horsepower per year than there are under this figure. Electric power can, not infrequently, be purchased for $60 per year, or even less, and the cost for attendance of motors is almost, if not quite, negligible. The depreciation is also small, the modern synchronous and induction motors being extremely reliable machines. The best of electric transmissions cannot compare with a local hydraulic power properly installed and distributed. Water wheels may be made light (that is, without much inertia, for such work as hoisting), or heavy (for fly-wheel effect, for driving compressors); they may be made of large or small power capacity, and for a great variety of speeds. We have in operation wheels of 1000 horsepower capacity, varying from 1400 feet head at eighty revolutions per minute to 500 revolutions per minute under 650 feet head. The great flexibility of the system permits the ready adaptation of these water wheels to almost any combination of speed, pressure and power.

An ideal water plant for mines is one where an ample quantity of clean water is available all the year round under a head of several hundred feet. Regulations may then be obtained by deflecting the water from the wheels without varying the velocity in the pipe line, and, therefore, for equal safety, with a cheaper pipe line, without the necessity of expensive safety valves and air chambers, to take up the water hammer due to the interrupted velocities. If water is purchased at a fixed charge, depending on the maximum requirement at any moment, and there is no storage capacity at the forebay, this system of stream deflextion may still be employed. It is also vastly better than any other when a fixed quantity must be allowed to flow to supply irrigation districts below. If, however, some storage reservoir, even though small, exists at the pipe intake or in the flume, then a great saving of water may be effected by the use of some form of regulating nozzle or cut-offs fitted in front of and arranged to slide over the nozzle outlet.

All of these devices introduce an element of some loss, and the actual power gained per unit of quantity is somewhat less than with a properly designed straight or deflecting nozzle with the proper size tips. The quantity of water for fractional loads, when the tips of the straight and deflecting nozzles could not be changed, is so much less as to make up to some extent, if not entirely, for the loss at full open stream.

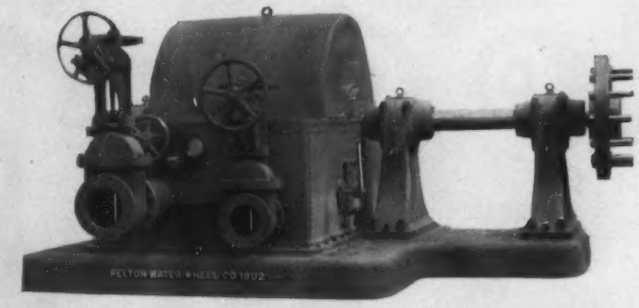
The relative values of the needle nozzle and cut-off, as water savers, depends entirely on the load variations. These should be plotted in the form of a load and time curve. The efficiency of the needle nozzle is not so high at full load; but the efficiency increases as the load falls off, so that if a plant is going to operate at a small fractional load for most of the time, the losses due to the short period of peak load will probably be more than offset by the gains at fractional load.

With the cut-off above mentioned, the contrary condition exists, viz., at full load the nozzle with a cut-off attachment is maintaining a maximum efficiency, and this falls off at fractional loads. It is obvious that if the efficiency of water wheels equippped with these two devices be plotted on the same sheet for varying loads and water quantities, the speed being maintained constant, that the curves will cross each other. This point of crossing will vary

*Abstract of a paper read before the Eleventh Annual Convention of the California Miners' Association, San Francisco, November 17, 18, 19, 1902.

in ordinary cases between 60 and 75 per cent. of the load for which the nozzle is designed. This shows us that if the mean daily load is above 60 or 75 per cent. of the maximum, then the cut-off will be the most effective water saver. If there are to be several units or several streams on the same wheel, then the operation of the cut-offs or needles should follow each other, and the point at which the needle will be more economical will drop to from 56 to 36 per cent. of the maximum load, and the greater the number of water jets used in the power development, the more efficient become the cut-offs and less efficient the needles, assuming that they operate consecutively, as they should, except for hoist, railway or rockbreaker loads, and even then unless these represent almost the total load on the plant.

This question of governing has been gone into at some length, as there seems to be a popular impression that it makes no material difference what form of apparatus be adopted for stream control—each water wheel builder advocating his particular hobby, as if it were a patent medicine. Such is not the case by any means, the water bills, or the maximum power obtainable from a given quantity of water, is directly influenced by the design of the nozzles and connections for the wheels. Nor is it wise to spend a considerable sum in the purchase of the most highly finished efficient wheel and then neglect all considerations of the nozzles and other parts influencing the result. In many instances better results will be obtained with a combination of different styles of regulating devices on the same wheel unit.



ASSEMBLED PELTON UNIT, CONSISTING OF TWO WHEELS OF DIFFERENT DIAMETERS FOR OPERATING FROM TWO SEPARATE PIPE LINES, UNDER TWO DIFFERENT PRESSURES, ONE WHEEL BEING PROVIDED WITH DEFLECTING NOZZLE AND THE OTHER WHEEL BEING FED BY A COMBINATION NEEDLE NOZZLE WITH STREAM DEFLECTOR, EFFECTING WATER ECONOMY

Many plants have been installed in the last few years where the regulation of tangential water wheels is automatically effected by a suitable governor controlling a deflecting nozzle or stream deflector and a cut-off or needle nozzle controlled by hand. By this arrangement the size of the stream is adjusted for the maximum load likely to occur within the hour, and the governor automatically diverts from the buckets that portion of the stream which is in excess of the load at any instant of time. In such work as railway and power transmission, where hoisting is done at certain hours of the day only, there are periods during which a considerable quantity of water could be saved by the readjustment of the size of the nozzle tip. The disadvantage of doing this by the governor, is that the velocity of the water in the pipe line is caused to fluctuate so suddenly as to produce a very serious ramming or water hammer effect on the line, which is not only dangerous, but, very naturally, increases the speed of any other water wheels which may be fed from it, thus impairing the regulation of the entire system. If we can save this quantity of water by regulating the size of the stream by hand and maintaining automatic governing by a governor, for instance, we can save considerable water and get the best possible regulation. The combination, therefore, of the deflecting nozzle and needle nozzle, or stream cut-offs, is in certain cases an extremely valuable one.

In regard to buckets the writer has never had much confidence in bucket shapes which are placed upon the market without exhaustive experimental work to demonstrate their value. There are very few buckets that we know of where the claim is not made that they are the most efficient on the market, and where any great care is exercised in proportioning them for the work they have to do. It is perfectly useless to put the proper shape bucket on a wheel unless its size is suited to the stream at which the best efficiency is desired. In some cases it may be better to determine the best efficiency point for an over-load of the driven machine; at other times at less than full load, depending entirely upon the mean normal load which the wheel is to carry.

Not only is the bucket shape of greatest importance, but, as pointed out above, the nozzles should also receive exhaustive consideration; the clearance around the wheel, the freedom of discharge through the tail-race, the gate valve and size of pipe, should all be carefully calculated. After a wheel is once installed, it should occasionally be overhauled to be sure that none of the buckets are missing, and that it is not wearing too fast. There are very few cases where the buckets will not last for a number of years, and it is believed that the best possible preservative is a good coat of special paint, which should be allowed to thoroughly dry before the water is again applied. This, of course, is not always possible, but in transmission plants there is usually one machine kept in reserve, and on this one the buckets may be painted, thus greatly increasing their life. In fact there is no reason why the life of the buckets may not be indefinitely prolonged, providing only they are kept properly painted. It is nothing unusual to find some of the older tangential wheels that have been in operation twenty years and upwards without the necessity of even painting them, but this is only where the quality of the water is of the best.

As to the relative advantages of different materials in bucket construction, there is much diversity of opinion. Where the head is less than 500 feet and the streams not particularly large, cast-iron buckets are very satisfactory. Above 500 feet the peripheral speeds become higher than it is safe to run the cast-iron, and gun metal, bronze or steel become necessary. In the small sizes of buckets it is very difficult to get satisfactory steel castings, and bronze or gun metal is therefore most frequently used. In large buckets, the gun metal and bronze are not as satisfactory as is the smaller sizes, and the expense becomes very heavy. Very good cast-steel may be obtained, however, and this is without doubt the best possible material for high head, large buckets.

Now for a few words on the numerous applications of tangential wheels, taking a few examples from actual practice.

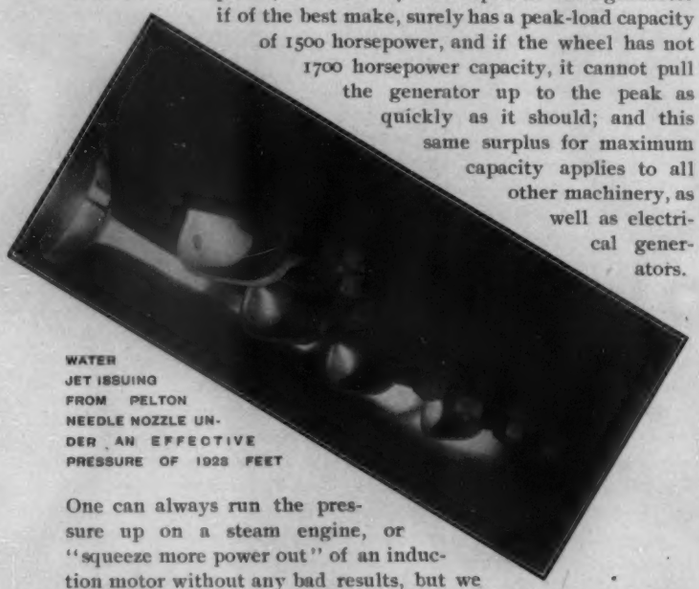
Larson & Greenough, at the Morning Mine, Mullan, Idaho, operate a large Rix compressor by three Pelton water wheels on the same shaft, two of them working under 140 feet head and one (33 feet in diameter) taking water from two streams—one under about 1200 feet and one about 1400 feet—the added power of all three streams being obtained on one shaft. Regulation is effected by stream deflectors under the high heads, and cut-offs on the low pressure nozzles—all controlled by a special governor controlling for both speed and pressure—the speed being automatically adjusted to maintain the pressure constant with all variations in load. The air is transmitted through over 12,000 feet of twelve-inch air pipe to tunnel workings.

At Ophir, Utah, one Pelton water wheel unit, consisting of two wheels on one shaft, drives an electric generator. Each wheel is supplied by a separate stream of water—one of these is of insufficient and varying quantity and the other of constant flow—the first is fed to the wheel by a double nozzle, one of the outlets being with a deflecting ball joint and one with a needle regulating nozzle. The regulation with the needle is by hand for the maximum load likely to occur within any hour, which is predetermined by the load curve, and the automatic regulation of speed and load by the shifting of the nozzles is then accomplished by a Lombard governor. In this way the most accurate regulation is obtained, without water hammer to the pipe, and the greatest economy of water is effected. There is some question as to the advisability of governing any plant by a direct application of the governor to the needle nozzle, on account of the unbalanced condition, except at one point, and, therefore, strong tendency to close or open. It is almost like a plug of wood or large round

rock plugging the tip in the event of a short circuit, or the breaking of a belt.

At Telluride, Colorado, on account of the high altitude and extreme winter cold, the water is very likely to freeze, more especially the discharge water, on account of the fine spray. The pipe line is long and the most accurate regulation is required, and, therefore, a deflecting nozzle is used. The interruption to the service in the winter time became so annoying that something had to be done to prevent freezing. The wheel pit was made of liberal proportions and curved plates set in the masonry, so that the discharge water from the deflected nozzles would circulate in the wheel pit, spreading out as it proceeded, thus introducing large air resistance. All air holes were closed up, and the outflowing water made to flow over a submerged weir, so that from exterior appearances it is impossible to tell whether the stream is on or off the wheel. This proved a perfect solution of the problem, and an interruption in the winter service is now unknown. A water wheel, if properly built and working under ordinary conditions, should be capable of continuous full duty every minute of the year, and there are many wheels that do not have a rest from one year's end to another.

A parting word about wheel capacity. One should not order a wheel of 1000 horsepower to drive a 750-kilowatt generator, or even 1200 horsepower, but rather 1700 horsepower. The generator if of the best make, surely has a peak-load capacity of 1500 horsepower, and if the wheel has not 1700 horsepower capacity, it cannot pull the generator up to the peak as quickly as it should; and this same surplus for maximum capacity applies to all other machinery, as well as electrical generators.



WATER JET ISSUING FROM PELTON NEEDLE NOZZLE UNDER AN EFFECTIVE PRESSURE OF 1923 FEET

One can always run the pressure up on a steam engine, or "squeeze more power out" of an induction motor without any bad results, but we cannot get more power out of wheels than the maximum in the stream.

In the case of the 750-kilowatt generator, the wheel should be constructed to give its maximum efficiency at from 1100 to 1300 horsepower, and maximum overload capacity of 1700 horsepower. This does not mean 1700 horsepower for a short period, but, if required to do so, 1700 for all the year round—that is, the strength of all parts should be designed with liberal factor of safety under this load. And every water wheel should be guaranteed by the maker to safely withstand the impact of the largest stream when locked in position, or when running at any speed it can attain under the pressure for which it is designed.

The enormous investments in water power properties, and the high running expenses, demand that water wheels be absolutely reliable, and a slight additional first cost to obtain this is as nothing compared to the enormous loss occasioned by the installation of any inferior wheels, which are invariably the cause of delays and shut downs.

This subject is too large a one to have touched on more than a few points, and special designs are required for almost every case, so that no specific rules can be given. There are, however, many wheels from which very much better results could be obtained, either in the way of more or cheaper power, if only the necessary attention was given to their installation, and there are, in addition, but very few plants where slight and comparatively inexpensive changes would not greatly improve the results.

Since writing the above an extremely interesting plant has been started up in southern California by the Edison Electric Company, known as their Mill Creek Station No. 3. In this plant is a combination Pelton needle and deflecting nozzle. The deflecting nozzle is operated by automatic governor and the needle is controlled by hand, the stream cross section being varied at different hours of the day to meet the maximum load requirements likely to occur for the hour.

The accompanying illustration shows the water jet on the needle nozzle when issuing under the effective head of 1923 feet. The remarkably high efficiency of 86.2 per cent. was obtained from this wheel at full load capacity, the measurements being conducted as carefully as possible, using hook gauges, and an extremely well constructed weir for the water measurements, and recording wattmeters for the electrical readings. The tests were conducted by Professor J. N. Le Conte of the University of California.

NEW ELECTRICAL ORDINANCE.

ATTENTION is directed to the passage of Bill No. 814, Ordinance No. 787, by the Board of Supervisors of San Francisco, providing new rules and regulations for the regulating and inspection, the installation and maintenance of electrical wires, appliances and appurtenances, construction and equipment in all of above buildings or other structures in the City and County of San Francisco, effective June 11, 1903.

Following is the text of the ordinance in full.

SECTION 1. Any corporation, co-partnership, association or individual, or agent thereof, owning, operating or in possession of any electric power or electric light and power plant; or any corporation, co-partnership, association or individual, or agent thereof, owning or in possession of any building or other structure within the City and County of San Francisco, shall permit an Inspector of the Department of Electricity to enter and inspect such plant or premises once in every three (3) months, or oftener if deemed necessary by the Chief of the Department of Electricity, for the purpose of ascertaining whether the electrical wires, appliances, apparatus, construction or equipment in, on or about said plant, building or other structure are in conformity with Section 1, Order 267 (second series), Board of Supervisors; and it shall be unlawful for any occupant or owner of premises where electrical wires, appliances, apparatus, construction or equipment are used, or to be used, or any person whatever, to prevent or interfere with any inspector in the discharge of his duties under this ordinance; provided, however, that said inspector shall, upon request of the owner or occupant of said premises, exhibit his authority to make such inspection, which shall be signed by the Chief of the Department of Electricity; and any such corporation, co-partnership, association or individual, or agent thereof, after notice in writing has been given by the Chief of the Department of Electricity that any portion of said electrical wires, appliances, apparatus, construction or equipment does not conform with the provisions of the National Electrical Code, as provided for in Section 1, Order 267 (second series), Board of Supervisors, shall make such repairs and alterations as may be necessary to make said electrical wires, appliances, apparatus, construction or equipment conform with said code; and failing so to do within five (5) days after said notice was given, the Chief of the Department of Electricity, or his authorized representative, shall, and he is hereby empowered, to disconnect said portion of said electrical wires, appliances, apparatus, construction or equipment so found to be not in conformity with said code; and the Chief of the Department of Electricity shall forthwith notify the corporation, co-partnership, association or individual, or agent thereof, supplying the electric power for said connection; and said corporation, co-partnership, association or individual, or agent thereof, shall not renew said power supply without permission from the Chief of the Department of Electricity.

SECTION 2. Every corporation, co-partnership, association or individual, or agent thereof, placing or installing electrical wires, appliances, apparatus, construction or equipment in, on or about any building or other structure in the City and County of San Francisco, shall before a certificate of inspection (as provided for in Section 2, Order 267, second series, Board of Supervisors) is issued by the Department of Electricity for the said city and county, pay to the Department of Electricity for such inspection the following fees, viz:

For each outlet at which current is controlled or used for four lights or under	$0.05
For each outlet at which current is controlled or used for over four lights	.10
For one arc lamp	.50
For each additional arc lamp	.25
For each motor of one horsepower or less	.50
For each motor of more than one horsepower and not more than three horsepower	1 00
For each motor of more than three horsepower and not more than eight horsepower	1.50
For each motor of more than eight horsepower and not more than fifteen horsepower	2 00
For each motor of more than fifteen horsepower	2.50
For each generator of one kilowatt or less	.50
For each generator of more than one kilowatt and not more than three kilowatts	1 00
For each generator of more than three kilowatts and not more than eight kilowatts	1.50
For each generator of more than eight kilowatts and not more than fifteen kilowatts	2.00
For each generator of more than fifteen kilowatts	2.50

Provided, however, as a minimum, the total amount of any bill of fees to be charged shall be not less than fifty (50) cents.

SECTION 3. When any corporation, co-partnership, association or individual, or agent thereof, after notice has been given in writing by the Chief of the Department of Electricity, shall be found to have intentionally or negligently violated any of the rules or regulations established under this ordinance; or when through any such violation by any corporation, co-partnership, association or individual, or agent thereof, doing the work, it is necessary to make extra inspections of the work, there shall be charged said corporation, co-partnership, association or individual, or agent thereof, for such extra inspection made necessary on account of such violation, a fee not to exceed seventy-five (75) cents per hour for the time actually consumed by each inspector making such inspection; provided, however, that this provision shall not apply to new work previous to the issuance of the certificate of inspection as aforesaid; and for the inspection of electrical wires, appliances, apparatus, construction or equipment, for which no fee is herein prescribed, and for the inspection of temporary installations for decorative, advertising, theatrical or similar purposes, there shall be charged to and paid by the corporation, co-partnership, association or individual, or agent thereof, installing such work, a fee not exceeding seventy-five (75) cents per hour for the time actually consumed by each inspector making such inspection, previous to obtaining the necessary certificate of inspection as aforesaid.

SECTION 4. It shall be the duty of the Chief of the Department of Electricity to turn all moneys received under this ordinance into the Treasury of the City and County of San Francisco.

SECTION 5. This ordinance shall not be construed to relieve or lessen the responsibility of any person owning, operating or installing any electrical wires, appliances, apparatus, construction or equipment for damages to any one injured by any defect therein; nor shall the city and county, or any agent thereof, be held as assuming any such liability by reason of the inspection authorized herein or the certificate of inspection issued by the Department of Electricity.

SECTION 6. Any corporation, co-partnership, association or individual, or agent thereof, violating any of the provisions of this ordinance, shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined not more than one hundred (100) dollars, or be imprisoned not more than ninety (90) days, or by both such fine and imprisonment.

SECTION 7. This ordinance shall take effect and be in force on and after the date of its passage.

In Board of Supervisors, San Francisco, June 1, 1903.

Approved, San Francisco, June 11, 1903.

E. E. Schmitz,
Mayor and ex-officio President of the Board of Supervisors.

PUBLICATIONS.

TELEPHONY, by Arthur V. Abbott, C. E. A new series of telephone books is announced by the McGraw Publishing Company, 144 Liberty Street, New York. Price, $1.50 for each volume, or if ordered at one time, $6.00 for the entire series.

Three volumes have already been issued and the other three will be forthcoming within a short time. Volume I deals with "The Location of Central Offices;" part II, "The Construction of Underground Conduits;" part III, "The Cable Plant;" part IV, "Open Wire Lines"; part V, "The Substation;" part VI, "Switchboards and the Central Office." These volumes will be handsomely illustrated and from the above captions, it will readily be seen will deal exhaustively with the subject matter. Mr. Abbott's reputation insures the value of this series of books to all of those engaged in practical telephony.

The Banker and Miner of Mexico has been purchased by Louis W. Buckley and associates. Mr. Buckley established the *Grocery World, Florida Trade Journal, Tobacco Record, California Orange Buyer* and other journals covering special fields. He has been elected president of the new company, and will be the general manager. Lawrence S. Vassault has assumed editorial charge. Mr. Vassault has been editorially connected with the *Argonaut, Cosmopolitan and Town Topics*. The publication under its new management will represent American capital invested in all business directions in Mexico.

INDUSTRIAL

"CHLORIDE ACCUMULATORS" IN RAILWAY SERVICE.

AMONG recent contracts for installations of the "Chloride Accumulator" in railway service, The Electric Storage Battery Company, of Philadelphia, has closed two with the Portland Railroad Company, located at Yarmouth and Underwood Park, Maine. The battery at Yarmouth consists of 216 cells, having a capacity of 134 kilowatt-hours, and is located midway from the power house on the same branch, and consists of 252 cells with a capacity of 604 kilowatt-hours. Contracts have also been closed with the Seattle Electric Company, Seattle, Wash., for a battery of 288 cells, having a capacity of 628 kilowatt-hours; the Waterville and Oakland Railway Company, Waterville, Maine, for a battery of 220 cells with a capacity of 205 kilowatt-hours; the Reading Power Company, at Reading, Pa., for a battery of 264 cells with a capacity of 740 kilowatt-hours. The Portland and Brunswick Railway Company, at Brunswick, Maine, have increased the capacity of their battery by the addition of plates, and the Camden Interstate Railway Company has contracted for the third battery of "Chloride Accumulators" on their system, this last one to be located at Huntington, West Virginia, and consists of 288 cells having a capacity of 314 kilowatt-hours.

INDUSTRIAL

S.K.C. CAST GRID RHEOSTATS.

IN putting upon the market the S.K.C. Cast Grid Rheostat, we feel confident that it is by far the best rheostat ever designed. It is the only rheostat wherein the resistance units are directly connected to the contact studs. In all other types, the units are connected to the studs by

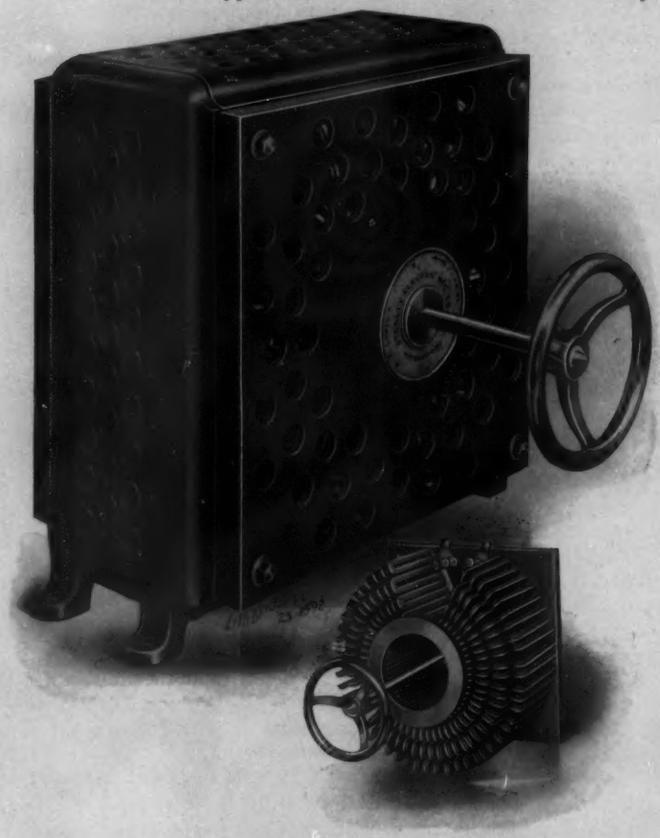


FIGURE 1. S.K.C. CAST GRID RHEOSTAT, COMPLETE AND WITH COVER REMOVED, SHOWING RADIAL ARRANGEMENT OF UNITS

wires, a construction which necessitates soldered contacts, set screws, or a combination of the two.

It is evident that the use of solder in a rheostat is highly objectionable, and, in practice, the set screws prove equally so, as they work loose and in other ways give rise to bad contacts. Moreover, short circuits sooner or later develop between the intercrossing wires as the insulation becomes impaired by the heat developed within the reheostat. The bulkiness of rheostats of the larger capacities has also been an undesirable feature of other types.

The S.K.C. Rheostat consists of fifty to sixty iron grids radially arranged, as shown in the lower part of Figure 1.

This arrangement results in an exceedingly simple and compact mechanical construction. Each unit, as shown in Figure 2, is formed with a projection extending at such an angle from the plane of the unit proper as to permit direct connection with the next unit.

A contact stud passes through two adjoining units, furnishing electrical connection between them and supporting them in place, and, at the same time, supplying a contact surface for the contact arm. Each unit is thus firmly fastened by two studs or bolts to the substantial slate slab through which the studs pass. A corresponding slate slab on the further side provides additional support to the units, resulting in a very rigid outfit and one of pleasing symmetry. The whole is mounted in a substantial and well ventilated iron case.

The resistance units are cast of such a shape as to furnish the best possible radiating and convective surface. The contact arm, as can be seen in Figure 3, is unusually broad, giving a good contact surface and permitting the ready dissipation of heat. In short, so absolutely free is the whole rheostat from weak points, that it may be briefly described as practically indestructible.

Jno. Martin & Co., 31-33 New Montgomery Street, San Francisco, Cal., are the agents for the Pacific Coast.

THE STILLWELL-BIERCE & SMITH-VAILE PUMPS.

THE Stillwell-Bierce & Smith Vaile Company have just issued a most interesting catalogue under the Caption of "General Catalogue No. 53," presenting in a most thorough and artistic manner the product of the Smith-Vaile Pumping Machinery.

As a volume of reference it will be useful to the engineer, giving as it does the most minute details regarding the Smith-Vaile

FIGURE 2. RESISTANCE UNITS

pumps, embellished by half-tones of the different types, which leaves nothing to be desired in forming a proper estimate of the efficiency of the machinery, space occupied and necessary data for installation. These catalogues, as also all further information, may be secured from the Pacific Coast office, 11-13 Front Street, San Francisco, or from the general offices, Dayton, Ohio.

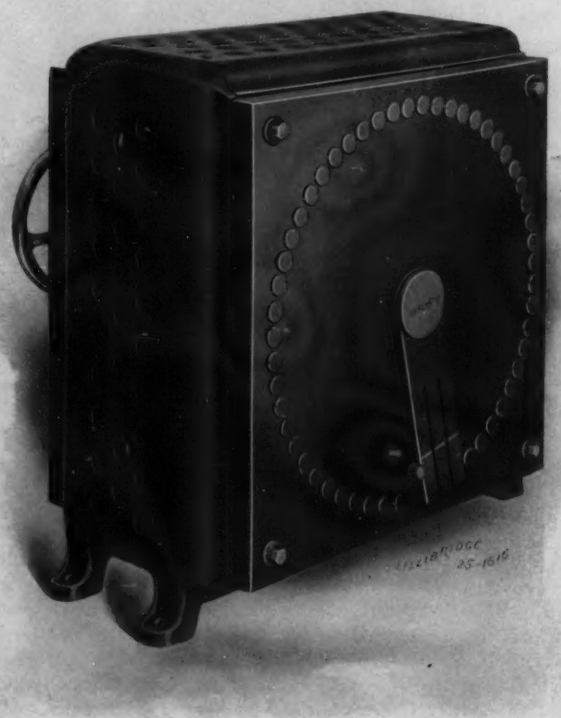


FIGURE 3. CAST GRID RHEOSTAT, CONTACT SIDE